Middle Creek Watershed Assessment

A Document of the Middle Creek Coordinated Resource Management and Planning Group

Prepared for:

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TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

PLATES

Middle Creek Watershed Assessment

1.0 Background

1.1 Watershed Assessment Purpose and Overview

This assessment is a document of the Middle Creek Coordinated Resource Planning group (MCCRMP). The purpose of the Middle Creek Watershed Assessment is to collect and integrate information on past and present watershed conditions and management. The assessment is intended as a tool to educate landowners on watershed conditions and management needs. It also describes how watershed conditions affect Clear Lake, immediately downstream of the Middle Creek Watershed. This assessment is a collection of available information on the watershed, and it helps to identify data gaps and future needs for information to understand watershed processes. It also provides a basis for watershed planning and identification of necessary watershed restoration and management projects.

Following this introductory section, the assessment begins with sections describing watershed resources and processes (Sections 2-15). The agencies and organizations involved in watershed management are covered in Section 16. Section 17 summarizes findings related to the watershed issues identified by the MCCRMP, identifies information gaps found during the assessment process, and lists recommendations for future activities.

1.2 History of the Middle Creek Coordinated Resource Management and Planning Group (MCCRMP)

The Middle Creek Watershed group formed as a Coordinated Resource Management and Planning (CRMP) group in 1999. The overall goal of the MCCRMP is protection and restoration of the watershed ecosystem. There group has defined four main components to meet this goal:

ECOSYSTEM IMPROVEMENT

- Identify desired future watershed conditions.
- Sustain adequate ground cover in order that siltation of waterways is minimized and wildlife habitat is maintained.
- Prevent discharge of pollutants before they can adversely affect water quality.
- Reduce the risk of erosion and sedimentation.
- Reduce the risk of flood damage to private and public property.

- Sustain, and where practical, increase native fresh water species.
- Create and sustain diverse riparian habitat and wildlife diversity.
- Develop a database of biological resources to monitor water quality.

FUEL MANAGEMENT

Develop a watershed approach to fuel reduction and fuel management in order to provide interagency support to both agencies and private landowners desiring to reduce fuel load and enhance woodland health including:

- Managing woodland resources through the thinning of overcrowded stands and brush fields, removal of dying trees, development of strategic fuel break locations, and the implementation of defensible space standards.
- Encouraging citizens to manage fuels on private property.
- Using the natural role of fire in this ecosystem to manage fuel loads through prescribed burning, particularly in areas dominated by fire dependent species, thereby reducing the risk of catastrophic wildfires.

ENHANCE THE VIABILITY OF HUMAN USES IN HARMONY WITH EACH OTHER AND ALL ANIMAL SPECIES THAT UTILIZE THE WATERSHED

- Manage the recreational use of the watershed to protect private property and the natural resources.
- Create a partnership with the agricultural community to protect, support, and enhance the ecological health and economic viability of the agricultural areas in the Middle Creek Watershed.
- Protect the rights and cultural heritage of the landowners in the watershed.

EDUCATION

- Promote the education of all interested individuals, organizations, and agencies with the best up to date information on the function and management of the watershed.
- Develop demonstration sites and hold workshops for landowner, stakeholder, and public education and awareness.

These activities, done effectively, will improve economic opportunities while ensuring a healthy watershed.

Figure 1-1 MCCRMP members and 4H kids rest after the 2003 creek clean up. *Photo courtesy of Greg Dills.*

The many achievements of the MCCRMP include:

- Surveying six miles of Middle Creek from Middle Creek Campground to Rancheria Road for erosion and invasive weeds, November 1999.
- Surveying portions of Alley and Clover Creeks for erosion and invasive weeds, November 1999.
- Assisting with Middle Creek restoration projects in cooperation with Robinson Rancheria grant, 2000-2002.
- Surveying sections of Lower Middle Creek for channel conditions, vegetation, and wildlife, 2005 and 2006.
- Writing a report summarizing the 2005 and 2006 surveys
- Holding monthly education and planning meetings.
- Holding annual creek clean up events.
- Staffing watershed information booths to help raise awareness at a variety of events including Upper Lake Wild West Days in June each year and the Lake County Fair in September.
- Providing letters of support for numerous grant funded projects.

Figure 1-2 MCCRMP members install a wildlife crossing sign. *Photo courtesy of Debbie Ickes.*

1.3 1999 Watershed Analysis

This assessment updates and builds on the Watershed Analysis Report for the Upper Lake Watershed (1999 Watershed Analysis Report) completed in 1999 as a joint project between the United States Forest Service (USFS) and Lake County. The area covered by the 1999 Watershed Analysis Report is equivalent to that defined as the Middle Creek Watershed for this assessment. The 1999 Watershed Analysis Report is an important background document for this assessment. It identified and analyzed four key issues: flooding, water quality in Clear Lake, fish and wildlife, and ecosystem restoration. Similar to this watershed assessment, no new data was collected, but data available at that time was used. Throughout the report, an attempt was made to compare current conditions with reference, or pre-European conditions, and to discuss how conditions had changed and what activities contributed to the changes. The appendices to the 1999 Watershed Analysis Report provide valuable supporting material. One appendix describes ecosystem characteristics and processes, while another describes upland vegetation and wildfire. Many of the findings and recommendations of the 1999 Watershed Analysis Report are still applicable to watershed conditions today.

While the 1999 Watershed Analysis Report was focused on four key issues, this Middle Creek Watershed Assessment attempts to assemble a comprehensive set of information on watershed resources and processes. In many cases, the 1999 Watershed Analysis Report is used as part of the background information for this document. In other instances, the reader is referred to specific sections of the 1999 Watershed Analysis Report where a comprehensive discussion of a particular subject is found.

1.3 Watershed Assessment Process

In December 2006, the West Lake Resource Conservation District (RCD) received proposition 50 funding for watershed planning and capacity building. As part of the grant, the MCCRMP followed the California Watershed Assessment Manual approach for watershed assessments and held stakeholder meetings to identify issues of concern in the watershed. While the scope of the assessment goes beyond these issues, this process helped to ensure that priorities of watershed stakeholders were addressed. The issues identified were:

- Protecting water quality.
- Ensuring water availability.
- Reducing wildland fire hazards[1].
- Encouraging abundant and diverse wildlife populations.
- Improving native fish habitat and populations.
- Restoring the lower Middle Creek channel (the confluence area and downstream).

2.0 Watershed Description

The Middle Creek Watershed is located in the Northern California Coast Ranges about 80 miles north of San Francisco. It is a sub-watershed of the Clear Lake Basin, located north of the town of Upper Lake (Plate 1). The Middle Creek Watershed lies almost entirely within the boundaries of Lake County, with only 0.5% located in Mendocino County. For purposes of this assessment, the Middle Creek Watershed is considered as the northern portions of the Upper Lake sub-area of the Upper Cache Creek Hydrologic Unit, which consists of Alley Creek, Clover Creek, and Middle Creek sub-watersheds. The low point of the watershed occurs where the original channel of Clover Creek joins Middle Creek.

Middle Creek is the second largest tributary to Clear Lake, which is the largest natural lake located entirely in California. At 50,155 acres, the Middle Creek Watershed comprises 16.5% of the Clear Lake Basin and contributes an estimated 21% of streamflow to Clear Lake.

Clear Lake has apparently existed as a shallow lake for at least 480,000 years because the lake basin has shifted downward at approximately the same rate that sediment fills it (Richerson et al. 1994). Clear Lake is not especially clear

[1] Wildlands are lands that are primarily in a natural condition.

as its name implies, but has been a eutrophic, or algae and plant rich lake, throughout its history (Sims et al. 1988). This abundant growth in turn feeds large fish and wildlife populations. Clear Lake drains to the east via Cache Creek into the Sacramento River.

Elevations in the watershed range from about 1,340 feet where Middle Creek and Clover Creek join, to 3,500 to 4,840 feet along the northern side of the watershed. High Glade Lookout is the highest point in the watershed. The east and west forks of Middle Creek start at the highest elevations in the watershed in the north eastern portion of the watershed. After their junction, at about 1,480 feet elevation, Middle Creek flows southeast past the town of Upper Lake and into Rodman Slough and Clear Lake. Alley and Clover Creeks drain the southeastern portion of the watershed and enter Middle Creek near the town of Upper Lake. Upper Lake is located near the lowest point in the watershed, in the center of the southern boundary of the watershed (Plates 2, 3).

North of the town of Upper Lake, Middle Creek and Clover Creek Valleys join to form a single, wider valley. South of the watershed is the "Reclamation Area", an area of reclaimed wetlands that is now used for agricultural purposes. Prior to levee building and draining, this was a large area of wetlands that were connected to Clear Lake. The area is now drained through Rodman Slough.

California Highway 20 crosses the watershed at the town of Upper Lake. Upper Lake (population approximately 1,000), in the center of the southern side of the watershed, is the only town in the watershed. The USFS is the largest landowner in the watershed. Mendocino National Forest (MNF) occupies 28,701 acres, 57% of the Middle Creek Watershed. In addition, there are 400 acres owned by the United States Department of the Interior, Bureau of Land Management (BLM) in the watershed.

3.0 Watershed History

At the time of European contact, Native Americans had been living in the vicinity of Clear Lake for at least 10,000 years, and they lived in balance with their environment. Most native people in the Middle Creek Watershed spoke the Eastern Pomo language, however, it was a transitional area with Northern Pomo speakers, who lived to the west of Clear Lake. Northern and Eastern Pomo people intermarried and traded with one another (McLendon and Oswalt 1978). At the time of European contact, native people were grouped in "tribelets", organized at the village level. Local villages included Sikom, located near the present location of Lucerne, Danoxa, in Clover Valley, Xowalek, in Upper Lake Valley, and Kayaw, in Tule Lake/Bachelor Valley. In 1878, members of these tribes joined together to purchase land near Upper

Lake at Xabamatolel. Later some of these people moved to the government purchased Robertson (sic) Rancheria (McLendon and Lowy 1978). The Upper Lake Habamatolel and Robinson Rancheria Tribes remain in the area today and are active participants in watershed conservation.

Prior to the arrival of European settlers, native people lived on the abundant natural resources available in the area. Harvested plants included acorns, buckeye nuts, grass seeds, roots and bulbs, berries, and edible greens. Game animals included deer, elk, rabbits, and squirrels (Bean and Theodoratus 1978). Fish were caught from Clear Lake and its tributaries. Near Clear Lake, fishing activities were concentrated on the spring spawning season when vast numbers of Clear Lake hitch, Sacramento pikeminnow and Clear Lake splittail filled the creeks surrounding the lake. These fish were dried and stored to be eaten for the rest of the year (McLendon and Lowy 1978). Northern Pomo speakers frequently built their houses of timber, while Eastern Pomo, in the vicinity of Clear Lake, used tules to build houses and boats, and for clothing including skirts, mantles, moccasins, and leggings.

While native people made extensive use of natural resources without apparently over-using resources, one way they may have actively modified their environment was through the use of fire. A compilation of references on the use of fire by Native Americans lists references for Pomo tribes in general and for Northern Pomo (Williams, G.W. 2003). The compilation gave a variety of reasons for which Native Americans used fire. These include clearing ground for acorn harvest, travel, hunting, and increasing food availability for prey animals. In addition, accidental fire starts would have occurred. A discussion of Native American use of fire is found in Appendix 1, Section A1.3 of the 1999 Watershed Analysis Report.

The arrival of Europeans was devastating for native peoples who were decimated by new diseases, forcibly relocated and forced to work for Europeans, and who were severely punished or killed for lack of cooperation. Near the Middle Creek Watershed, south of the town of Upper Lake, Bloody Island is the location where a terrible massacre of local Indians was carried out by the United States Army in 1850.

With the arrival of European Americans, extensive changes in watershed conditions occurred. Historic land use activities and watershed changes are thoroughly documented in section 7.4 of the 1999 Watershed Analysis Report, and are summarized below.

Livestock including cattle, horses, sheep, goats, and pigs, foraged throughout the watershed. Sheep were most numerous from the 1860s to 1920s. Sheep grazing began in lower valleys in the spring and moved uphill to higher forests and meadows during the summer. In the fall, the herds were driven back to the valleys, and fires were often set at this time to improve forage for the following year. These activities significantly damaged riparian areas, and "combined with the extensive logging going on at the same time, this threatened to eventually deforest the entire watershed" (USFS 1999). Erosion and sedimentation probably increased over pre-European levels, however, forest fires were probably less intense due to lower fuel levels. Grazing came under a permit system when MNF (then the Stony Creek Reserve) was first established. Sheep and goat grazing peaked in 1912 at 61,000 head and cattle grazing peaked in 1922 at 11,600 head. Only cattle's grazing continues on MNF land today.

Numerous sawmills opened in upper portions of the watershed beginning in the late 1860s, and logging continued until most accessible timber had been cut in the 1930s. In the late 1940s increasing lumber prices made it economically feasible to build roads to mountainous areas, and by the 1970s road building had opened up almost all timbered areas of the watershed. "Selective removal of commercial conifer trees gradually converted many conifer plant communities to mixed conifer-hardwood types" (USFS 1999).

Beginning in the 1910s, fire prevention and suppression became the policy of the USFS and State of California. Over time, this led to more dense brush lands (chaparral) and forests, and more understory vegetation in timber stands. Dense conifer reproduction has increased tree density while reducing average tree age and diameter relative to former conditions. Programs to reduce fuel loading in chaparral areas resumed in the 1950s and have continued until the present time (USFS 1999).

At a meeting of the MCCRMP in March 2008, longtime residents of the Middle Creek Watershed described changes they had observed in life style and natural resources[2]. These descriptions both confirmed and added to the land use description in the 1999 Watershed Analysis Report. Local residents described how cattle and sheep herders coming down from the mountains in the fall used to set fire to improve forage, and used to leave poison behind to kill coyotes. They observed much higher deer populations in the 1950s in the Middle Creek Valley and surrounding hills than are present today. Other changes in wildlife populations included the arrival of turkeys in the area about 20 years ago, and the fact that buzzards remain in the area year round, rather than migrating south in the winter. In the 1960s, Clear Lake hitch were so plentiful on Middle Creek that local children would catch them by clubbing them, a common pastime called "hitching". Longtime residents could also remember local Native Americans drying rows of hitch on fences and other structures.

Longtime watershed residents described how logging trucks were once common on Elk Mountain Road, and how the last sawmill in the area closed

[2] The longtime residents who spoke were Anita Crabtree, Ed Dutcher, Matt Hutton, Ed Seely, and Alex Suchan.

in 1952. They described how local farms in the early 1940s were mixed farms with a few dairy cows, hogs, chickens, and walnut trees, and most farmers still used horse teams for their farm operations. Many farmers brought milk to a cheese factory in Upper Lake. The diversified farms changed after World War II when tractors became more common, and in the 1950s commercial scale orchards of pears and walnuts were planted. A 1949 survey of crops confirms this picture with about 1,400 acres of alfalfa and pasture, 290 acres of beans, 180 acres of pears, 40 acres of corn and other grains, 30 acres of walnuts, and 15 acres of truck crops present in the Upper Lake area (SCS 1951). A cannery where beans and other vegetables were canned operated in Upper Lake from about 1900 to as late as 1967 (Lake County Coordinating Council 1967).

Countywide, the areas of walnuts and pears peaked in about 1980 at about 10,000 acres of walnuts and 8,000 acres of pears. By 2005, there were 2,800 acres of walnuts and 2,500 acres of pears countywide (LCDA various). As of 2001, there were 1,027 acres of orchards (fruits and nuts) in the Middle Creek Watershed[3]; however, there has been a continuing decline in pear acreage since that time. Beginning in the 1980s, winegrape acreage has increased from 3,000 to 8,500 acres today in Lake County (LCDA various); however very little of this, 187 acres[3], is located in the Middle Creek Watershed.

In the March 2008 meeting, longtime residents described changes in water resources. They remembered that Clover Creek once ran year round, and trout were present. Middle Creek also flowed year round, although it went underground in some places. Following the Fork Fire in 1996, Middle Creek ran longer than it had in previous years. Matt Hutton, a well driller along with his father, Jack Hutton, noted that static well levels have declined as much as 50 feet in some areas. Flooding was severe in Upper Lake in 1938, 1955, and 1957-58 prior to the Middle Creek Flood Control Project that improved levees in many areas to prevent flooding (<u>Figures 3-1</u>, <u>3-2</u>).

[3] Based on DWR 2001 land use data.

Figure 3-1 Winter flooding in Upper Lake circa 1900.

Figure 3-2. Flooding at the corner of First and Main in Upper Lake, 1955.

4.0 Geology

The California Coast Ranges were created when ocean and continental plates collided and "sediments, submarine volcanoes, and oceanic crust were scraped from the down-going plate and attached to the North American plate" (Moores and Moores 2001). This process of subduction created the

Franciscan Complex, the mixture of rocks comprising much of the California Coast Ranges. Along the eastern side of the Coast Range, the ocean sediments were tilted upward, but not jumbled to the extent of the Franciscan Complex, and this geologic formation is called the Great Valley Sequence. Movement of tectonic plates on the California coast later produced a series of faults paralleling the San Andreas Fault. These faults create the north/northwest-south/southeast valleys and ranges seen in the Coast Ranges (Christensen Associates Inc. 2006).

Much of the Middle Creek Watershed is underlain by the Franciscan Complex, or Franciscan Mélange, described in Roadside Geology as “one of the world’s great messes. It is a wild assortment of sedimentary rocks, deposited in seawater at many depths and in widely separated parts of the ocean, along with generous slices of the basalt ocean floor” (Alt and Hyndman 2000). The most common type of rock in the Franciscan Complex and in the Middle Creek Watershed is sandstone, or greywacke, a sedimentary rock (Plate 4). Mudstone is a variation of this sedimentary rock made from finer clay and silt-sized particles. Other rocks were formed by alterations of the ocean crust. Greenstone, found in a small area of the southern portion of the Middle Creek Watershed, is metamorphosed volcanic rock (basalt) from ocean plates. Blue schist is a hard rock, ranging in color from blue to black to grey. It is formed by metamorphism of oceanic basalt and rocks of similar composition under conditions of high pressure and low temperature (Alt and Hyndman 2000, Wikipedia 2009).

Middle Mountain, separating Middle Creek from Bachelor Valley, is an outlier of sedimentary rocks from the Great Valley Sequence (ESA 1978). In Plate 4, it is the portion of sandstone of more recent origin.

Alluvium, unconsolidated material deposited by the action of streams and rivers, fills the low-lying valleys of the Middle Creek Watershed. As could be expected, older material is overlain by more recently deposited material.

The Clear Lake basin was created by the interaction of faults in the San Andreas system. The area underlying the main portion of the Clear Lake basin began to subside about 600,000 years ago in association with the eruption of a portion of the Clear Lake volcanic field (Hearn, B.C. and R.J. McLaughlin 1988). The lake has remained shallow with the rate of downward vertical movement of the basin roughly equal to the rate of sedimentation (Richerson et al. 1994).

Clear Lake is on a topographic divide between the Russian River system and the Sacramento Valley system, and its outlet has alternated between the two systems. When the lake first formed, it flowed east to the Sacramento Valley as it does today. About 200,000 years ago, activity of the Clear Lake Volcanics, blocked off the outlet, and the lake rose until it found a new outlet, draining west through Blue Lakes into Cold Creek and the Russian River. Sometime within the last 10,000 years, a landslide at the west end of Blue Lakes blocked off the outlet, and the lake again rose until it created today's outlet to the Sacramento River (Enderlin 2007).

5.0 Soils

Soils are formed by weathering of rock at or near the earth's surface. Major factors influencing soil formation in the Middle Creek Watershed include the type of rock or unconsolidated material on which they formed, and the topography of the area where they formed. As a general rule, soils are shallower as slopes become steeper due to naturally higher rates of erosion. They are deepest in valley locations where eroded materials accumulate.

The majority of the Middle Creek Watershed is moderately to very steep terrain where soils formed on sedimentary rocks (92% of watershed area) or a combination of sedimentary and metamorphic rocks (1% of watershed area) (Plate 5). The Soil Survey (SCS 1989) describes most of these soils as gravelly and very gravelly loams overlying fractured sandstone. Depending on the soil type, the depth to bedrock (fractured sandstone) can range from 1-6 feet. Many of these soils are described as having rapid surface run-off and severe erosion hazard (SCS 1989).

Alluvial soils, formed on sediments and gravels transported by streams and rivers, are found in level valleys and cover 7% of the watershed. Of the approximately 3,500 acres of alluvial soils in the Middle Creek Watershed, two-thirds of them are covered by Lupoyoma and Still loams, both Class I agricultural soils. Class I soils are deep, with sufficient water holding capacity and drainage to grow most crops.

6.0 Hydrology

6.1 Physical Description

The west fork of Middle Creek drains the northwest portion of the watershed. It starts at an elevation of 3,040 feet and flows southeast for 6.5 miles to the confluence with the east fork (Plate 3). The east fork of Middle Creek drains the central northern portion of the watershed, flowing northwest for 9.5 miles with an elevation drop from 4,200 feet to 1,480 feet. From the confluence at the Middle Creek Campground, Middle Creek flows southeast 6.7 miles to the Clover Creek diversion channel, and an additional mile to the watershed boundary at mouth of Clover Creek at approximately 1,340' (USFS 1999).

Clover Creek drains the southern portion of the Middle Creek Watershed. Starting at 3,680' elevation it flows 8.5 miles northwest to its confluence with

Middle Creek at 1,340' in elevation. Two tributaries to Clover Creek, Gilbert and Alley Creeks, start at similar elevations to Clover Creek. Gilbert Creek flows 5.5 miles along the southern edge of the watershed to join Clover Creek, and Alley Creek flows 6.5 miles to its confluence with Clover Creek, draining land to the north of Clover Creek USFS 1999).

6.2 Diversions and Barriers

Surface water diversion (removing water from a water body) is regulated by California water rights laws. Both riparian and appropriative water rights[4] are supposed to be registered with the State Water Resources Control Board Division of Water Rights; however, only appropriative water rights require reporting of the amount of water taken. Therefore, it is not possible to estimate the total amount of water diversion in the Middle Creek Watershed based on Division of Water Rights records.

Several man-made barriers to fish passage in lower sections of Middle and Clover Creeks have been documented (Plate 3); however, a complete and systematic survey has not been carried out. The focus on fish passage has been for the Clear Lake hitch (*Lavinia exilicauda chi*). Because hitch are not strong swimmers, barriers that create waterfalls of one foot or more can partially or completely block their passage (Macedo 1994).

The Rancheria Bridge, located about ½ mile upstream from the Clover Creek Diversion, has a sill that was installed in 1960-61 by the California Department of Water Resources (DWR) to provide a control section for the stream gage mounted on the bridge. Downcutting of approximately 4 feet occurred below the sill, creating a barrier to hitch and rainbow trout passage (Figure 6-1).

In 2005, a series of four rock weirs were built by the Lake County Public Works Department (LCPWD) across Middle Creek below Rancheria Bridge for the purpose of improving fish passage and to stabilize streambanks. Repairs to the weirs were made following damage caused by high flows of the 2005 News Years Eve flood. The weirs are designed to create steps of no more than one foot in height once they have filled in with gravel. The weirs are designed with a lower level in the center to direct flows away from streambanks to the center of the weirs (LCWPD 2002). Although there is some concern that the weirs create a channeled and swift flow that prevents

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[4] The SWRCB Division of Water Rights keeps records of all legally recorded riparian rights and water appropriations in the state. Riparian rights apply to lands immediately adjacent to a water course and entitle the landowner to use a small amount of water for domestic or agricultural use. Riparian rights do not permit storage for use during the dry season or to use on land away from the water course or in another watershed. Appropriative water rights apply to water use on non-riparian land, or to use of more water than allowed under riparian rights. The Division of Water Rights requires registration of, but not a permit for, riparian rights, and reporting the amount of riparian water use is not required on the registration. To receive appropriative water rights, the water user is required to apply for a permit and to report the amount of the water appropriation.

hitch passage (HPUL 2006), hitch were observed above the bridge in 2008 (CCCLH 2008).

Figure 6-1 Rancheria Bridge and the sill below, April 30, 2004.
Photo courtesy of Greg Dills.

As part of the Middle Creek Flood Control Project built by the United States Army Corps of Engineers (USACE) from 1959-1966, a weir was built in the Clover Creek Diversion Channel. The purpose of the weir was to alleviate flooding during winter months and provide flows in spring and summer for groundwater recharge through the historic channel of Clover Creek in the town of Upper Lake. Because the weir created a barrier across the creek, it trapped gravel behind it that plugged the drainage culverts designed to provide base flows in the historic Clover Creek channel. The weir also created a barrier blocking passage of Clear Lake hitch. To permit fish passage and reduce annual costs for gravel and sediment removal, LCPWD modified the weir in 2007. This modification involved a 2'deep, 60' wide notch across the center of the weir (Figure 6-2).

Figure 6-2 Clover Diversion Weir after modification and winter rains, March 4, 2008. *Photo courtesy of LCDPW.*

6.3 Climate

California's North Coast has a Mediterranean climate with moderate, wet winters and warm to hot, dry summers. Long term average monthly temperatures and rainfall for Upper Lake are shown in Figure 6-3. Freezing temperatures occur from October through April during most years. These temperatures require protection for frost sensitive crops during the months of March and April and occasionally into May. The monthly averages understate the maximum temperatures, which exceed 100^{o}F during summer months in most years.

Mean annual precipitation in Upper Lake is 34 inches. Precipitation increases at higher elevations, reaching 55 inches in the upper watershed (Plate 6). There is very little snowfall at lower elevations in the watershed, and even at higher elevations there is usually no snow pack formation (USFS 1999). It is relatively rare, therefore, for melting snow pack to contribute to flooding.

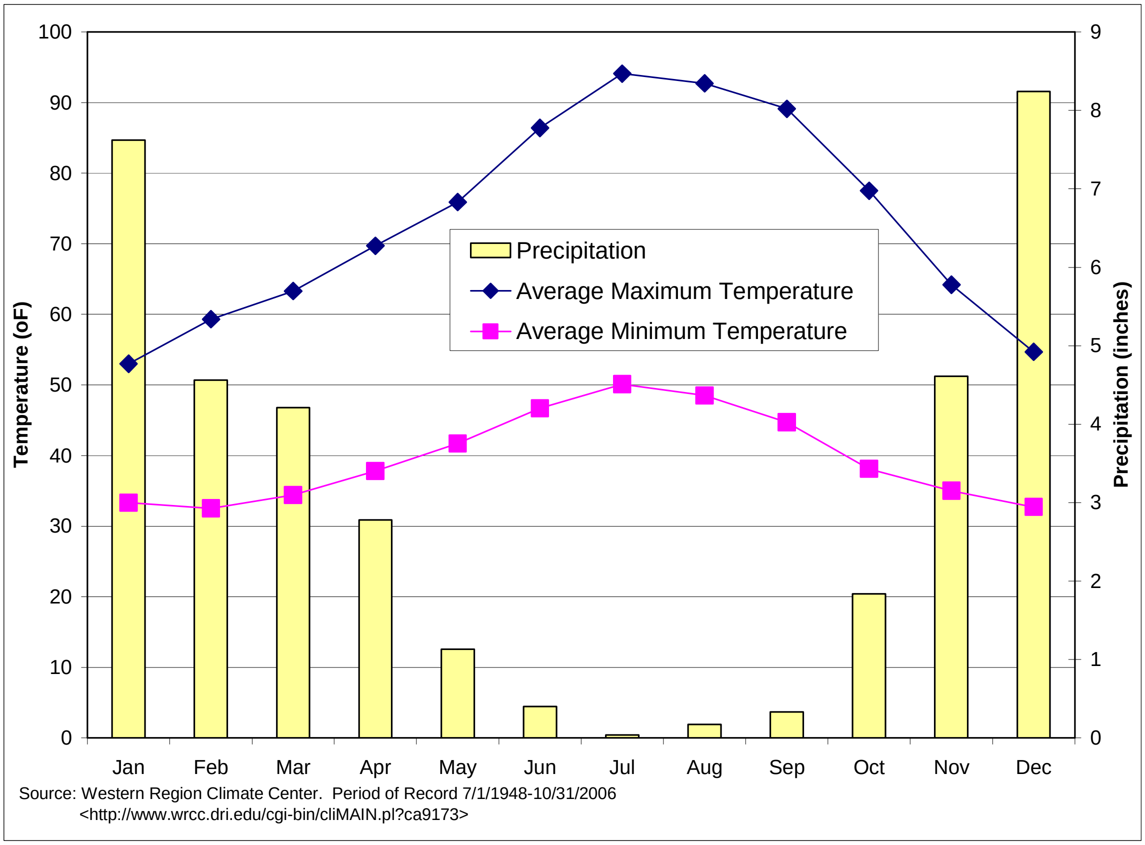


Figure 6-3 Mean monthly temperatures and precipitation for Upper Lake, California.

6.4 Streamflow

There is one stream gage on Middle Creek, located at the Rancheria Bridge, upstream of the Clover Creek diversion channel (Plate 3). Due to its location, the station measures flows from Middle Creek, including both the east and west forks, but it does not include Alley and Clover Creeks. By area, the station gages 64% of the watershed. The average annual flow for this gage, 73.3 cfs, encompasses dry periods and all flow rates over the entire year (Table 6-1). Assuming that streamflows draining the remainder of the Middle Creek Watershed would be proportional to watershed area, the total flow for Middle Creek at its mouth would be 114.6 cfs or 82,933 acre-ft/year.

Table 6-1 Summary of stream gage data.

Operating Agency & Station No.	Location	Average Annual Flow (cfs)	Period of Record (years)	Gage Area (miles^2)
DWR A81810	Rancheria Bridge	73.3	1967-2008	50.1

In Figure 6-4, annual average flows are shown by water year[5]. Annual average streamflow in Middle Creek varies greatly depending on annual precipitation[6]. Inferences about missing annual flows can be made based on flows measured in Scotts Creek, a watershed immediately to the south of Middle Creek with similar climate, topography, geology, and size of the watershed and gaged areas. The lowest recorded streamflow in Middle Creek occurred in 1976. However, based on Scotts Creek flow records, it is likely that the flow was lower in 1977. Also when compared to the more complete record on Scotts Creek, it is likely that the highest annual average flow in Middle Creek occurred in 1998, as shown in Figure 6-4. However, the second two highest annual average flows recorded on Scotts Creek for the 1983 and 1995 water years, were not recorded for Middle Creek. DWR did not operate the Scotts or Middle Creek stream gages in Lake County during the 2006 water year. Therefore, the flows during the 2005-2006 New Year's flood were not recorded.

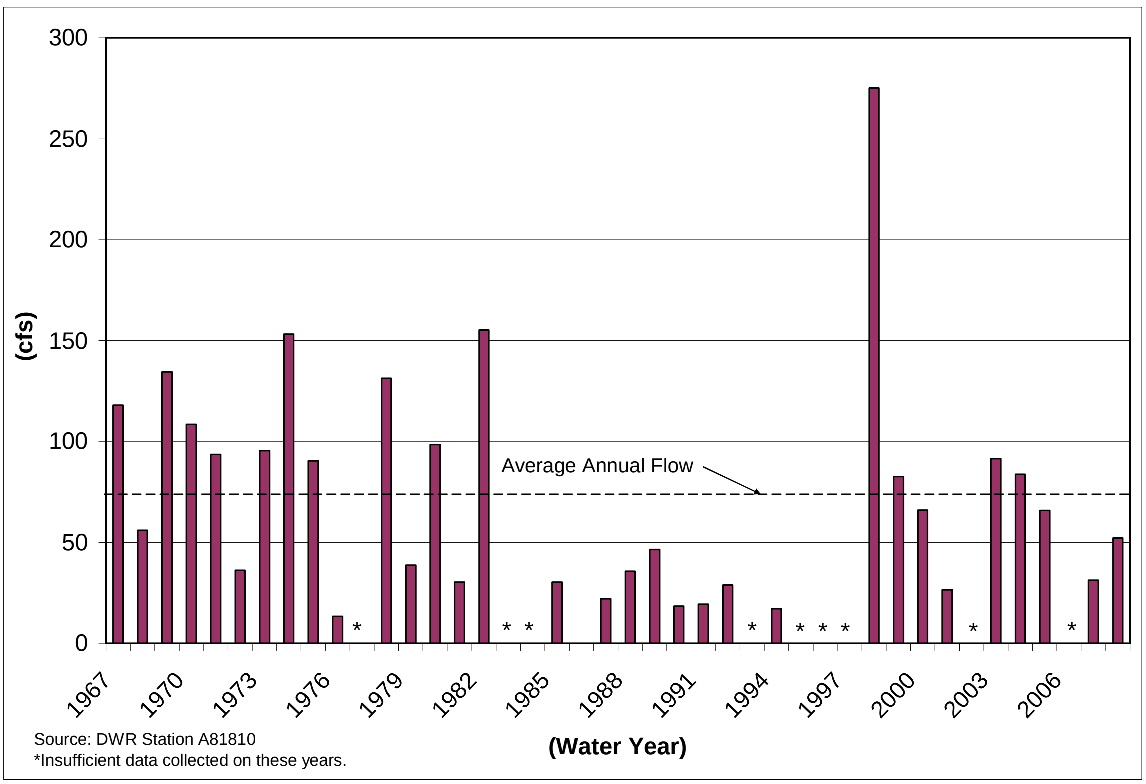


Figure 6-4 Annual average streamflows in Middle Creek at the Rancheria Bridge.

The peak streamflows for each water year are shown in Figure 6-6. These are instantaneous flows (measured every 15 minutes), rather than the average

[5] The water year goes from October 1 to September 30 and is designated by the year in which it ends.
[6] Annual average flow indicates the flow rate averaged over an individual year. Average annual flow indicates the long term (many year) average of annual average flows.

flow for the entire year, so they are much higher than annual average flows. Statistical analysis of these peak flows is used to determine the probability that a flow of a given magnitude will occur in any given year. For example the 100 year peak flow (or 100-year flood) has a one in one hundred (1 %) chance of occurring in any given year. In Figure 6-6 the 1.5 and 100 year peak flows are shown. The 1.5 year recurrence interval corresponds approximately to the bankfull stage of streamflow, or the flow at which the stream is flowing to the top of its banks (Figure 6-5). This flow level is most important in forming the stream channel (Leopold, L.B. 1994). The 100 year peak flow corresponds to what is termed the 1% annual chance flood or the 100 year flood.

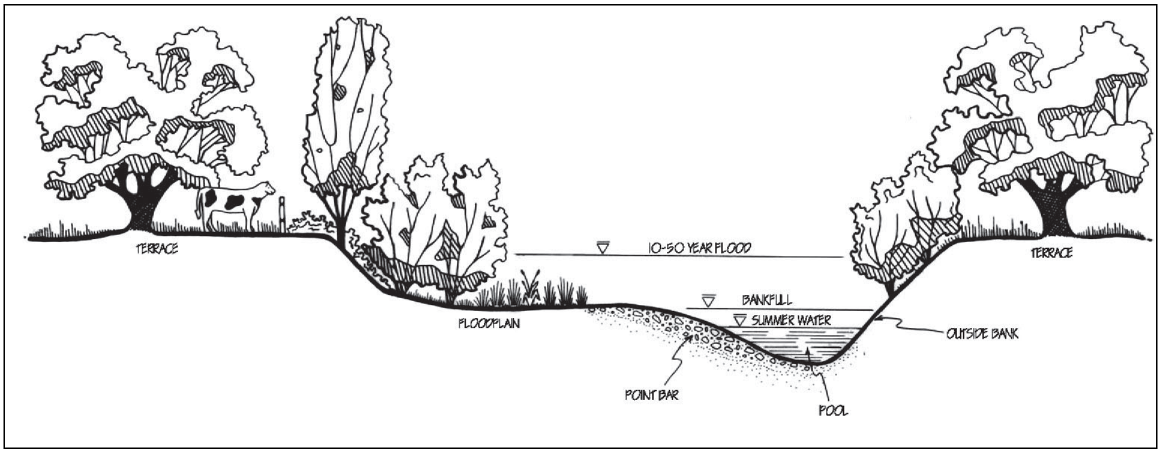


Figure 6-5 Cross-section of a stream channel. *Figure courtesy of Marin Resource Conservation District, 2007.*

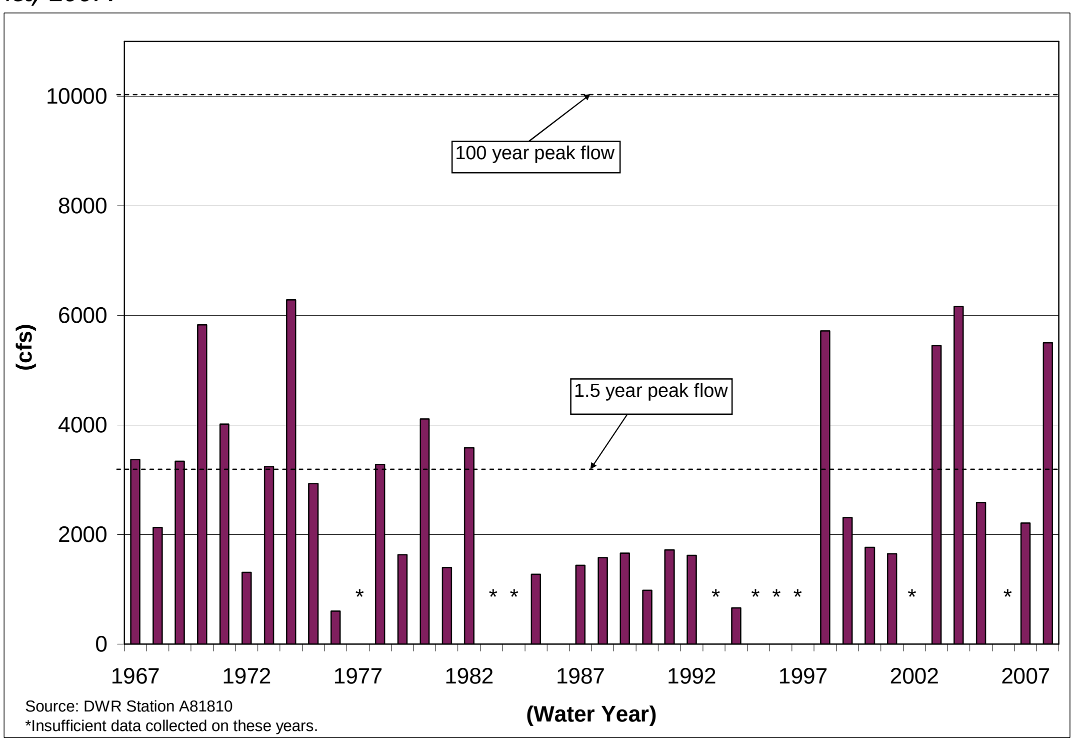


Figure 6-6 Annual peak flows in Middle Creek, measured at the Rancheria Bridge.

Average monthly streamflow is shown in Figure 6-7. The beginning of streamflow lags one to two months behind the seasonal pattern of precipitation (Figures 6-3, 6-7). For example significant precipitation occurs in October, but significant streamflow does not occur until November. Peak average monthly precipitation occurs in December; however, peak monthly streamflow occurs in February.

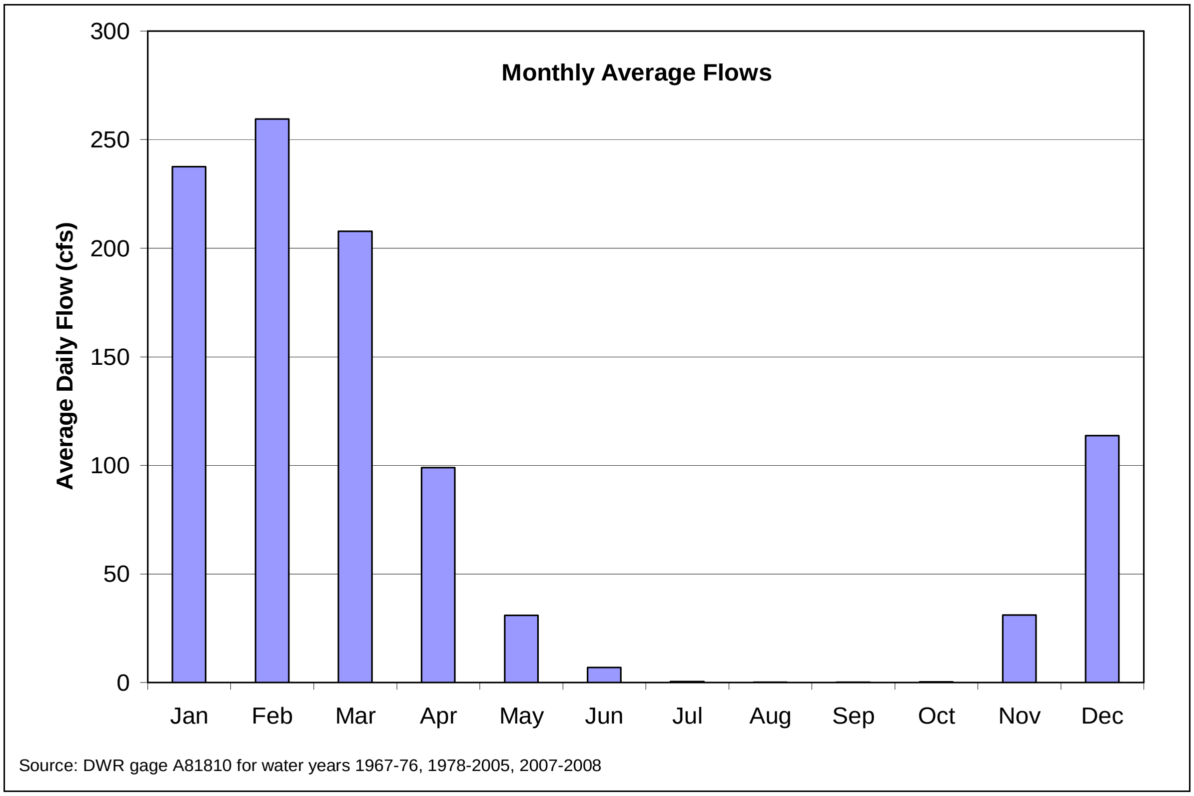


Figure 6-7 Monthly average flow rates for Middle Creek at Rancheria Bridge.

6.5 Groundwater

The most significant groundwater resource, and the only one that has been well documented, is the aquifer system underlying Middle Creek and Clover Valleys, referred to here as the Upper Lake groundwater basin (ESA 1978). Although this aquifer system is depicted extending south to Clear Lake (Figure 6-8), there is little information on groundwater resources in the area south of Highway 20. Because plans are in place to restore the area to wetlands, it is unlikely that groundwater resources there will be used in the future.

The highest yielding wells in the Upper Lake groundwater basin come from the confined aquifer system (Figure 6-8). This aquifer system consists of clayey gravel and sand, with lenses of cleaner sand and gravel. The confined aquifer system is overlain by finer (silt and clay) lake and floodplain deposits (ESA 1978). The confined, gravelly aquifer system is about 70' thick to the north, overlying bedrock. Farther south it thins and partially inter-fingers with, or overlies, older lake sediments. The confined, gravelly aquifer system grades into the free groundwater aquifer system, which provides recharge to the confined aquifers. The free groundwater aquifer system consists of sandy, gravelly channel alluvium in the stream channels, and gravel with sand and finer materials in alluvial fans surrounding the valleys.

The estimated size of groundwater resources in the Upper Lake groundwater basin north of Highway 20 is shown in Table 7-1. Total groundwater storage was estimated at 11,997 acre-feet. Usable or safe yield was estimated as 50% of total storage. Water use for agriculture begins in the spring while the aquifers are still being recharged. Therefore, an additional 1,617 acre-feet of spring recharge replaces spring water use to give a total of 7,616 acre-feet of usable groundwater.

Other studies describing Upper Lake Basin groundwater supplies appear to be less reliable. The Lake County Water Inventory and Analysis (CDM and DWR 2006c) stated that ESA (1978) estimated total groundwater storage in the Upper Lake Basin to be 9,000 acre-feet. However the actual numbers from ESA (1978) are given in Table 7-1 below. CDM and DWR (2006c) also appear to incorrectly cite a 1957 DWR study of Lake County groundwater resources. The actual estimates in DWR (1957) are a total groundwater storage capacity "in free ground water zones" of 10,900 acre-feet in the Upper Lake unit, and safe ground water yield of 10,500 acre-feet.

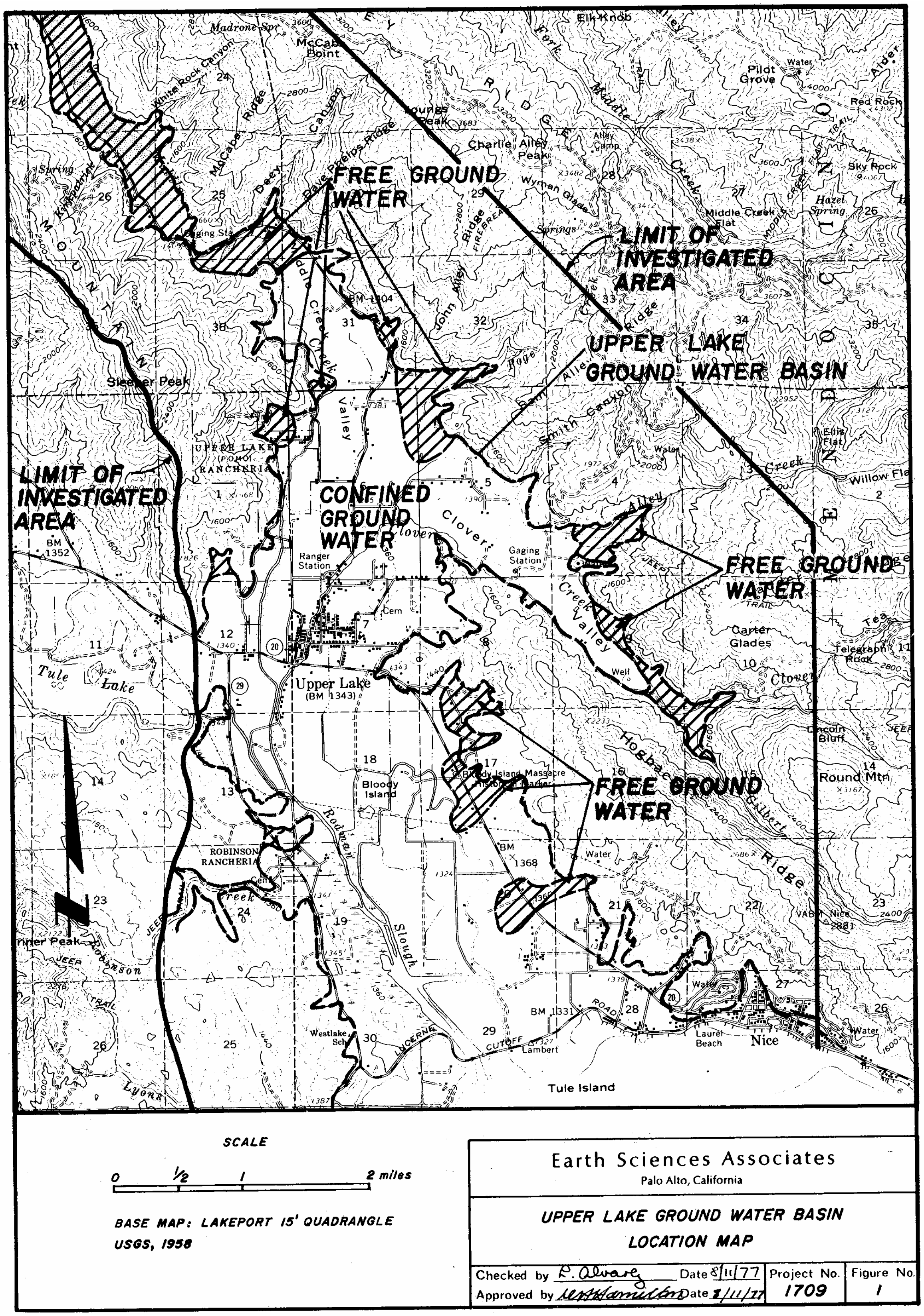


Figure 6-8 Upper Lake ground water basin mapped in 1977 (ESA 1978).

Table 7-1 Groundwater resources in Middle Creek and Clover Valleys.

Aquifer or other source	Total Groundwater Storage (acre-feet)	Usable or Safe Yield (acre-feet)
Unconfined aquifers of recharge areas	1,380	690
Middle Creek Valley confined, gravelly aquifer	9,500	4,750
Clover Valley confined, gravelly aquifer	1,117	559
Spring infiltration recharge		1,617
Total Groundwater	11,997	
Total Available Groundwater		7,616

Source: ESA 1978. This study also included an estimate of groundwater availability in the capping layer of lake and floodplain deposits, however well yields from these deposits are quite low, and wells are unlikely to use these deposits. Safe groundwater yield was estimated as 50% of total yield.

7.0 Hill Slope and Stream Channel Geomorphology and Processes

7.1 Erosion

Erosion is a natural geologic process. Through erosion, hills and mountains are gradually worn down, and sediment is deposited in valleys, lakes, and bays. Accelerated erosion occurs through human activities such as livestock grazing, cutting forests, plowing sloping land, disturbing land for construction of roads and buildings, stream channelization, and development that reduces land permeability and concentrates streamflows. Accelerated erosion leads to soil degradation when topsoil is lost and to increased sediment loads in streams and lakes that reduce water quality. (Sections 8.1, 8.3)

Several factors influence erosion of the soil surface. Surface erosion is generally inconsequential on level ground and increases as the slope of the land increases. There is also greater erosion potential as the length of sloping ground increases. The amount and intensity of rainfall influence erosion as do soil properties such as texture and permeability. Cover by vegetation or other materials has a major influence on soil erosion. Bare soil is much more likely to erode, and covering it with living vegetation, mulches or other materials is one of the best erosion control methods. Other soil conservation practices include contour tillage and construction of terraces.

Landslides are the down slope movement of large masses of sediment and rocks, largely due to gravity. They can be set off by natural causes such as heavy rainfall, earthquakes and, floods; and by human activities such as grading, terrain cutting, and filling. Three factors contribute to the potential for landslides, the steepness of the terrain, consolidation of the materials that make up the slope, and the amount of water which loosens the materials (USSARTF 2008). Landslides have the potential to cause sporadic, but very large sediment loads to stream systems.

Roads, especially unpaved roads, can be major sources of erosion (Plate 7). The Lake County Public Works Department has mapped 26 miles of paved roads, and 201 miles of unpaved roads, trails, and firebreaks in the Middle Creek Watershed. Surface erosion from roads can be a chronic source of fine sediment. Road failures, especially when large storm events cause multiple failures, contribute large sediment loads to streams. Operation of motorized vehicles off of developed roadways and trails contributes to both hillside and stream bank erosion.

Developed areas, even at low densities, contribute to increased long term erosion potential. In these areas, impervious surfaces increase surface run-off, and flows are concentrated in ditches and other water conveyance structures. Streams are frequently channelized, straightened and/or deepened, for development or agricultural purposes. Channelized streams have the potential to carry higher peak flows and therefore greater sediment loads. Higher peak flows also contribute to greater downstream flood potential.

Agricultural tillage both loosens soil and removes soil cover. It increases erosion risk primarily on sloping ground. The two crops commonly grown on sloping ground in Lake County are walnuts and wine grapes; however, there is very limited hillside acreage of these crops in the Middle Creek Watershed. While livestock grazing can remove vegetative cover leading to erosion on hillsides, the greatest erosion impacts of livestock may be damage and removal of riparian vegetation and stream bank erosion.

Studies of sediment cores from Clear Lake found that the impacts of human activities on soil erosion in the Clear Lake watershed became obvious following the advent of heavy earth-moving equipment in about 1927. At this time, the sedimentation rate in the lake increased approximately ten-fold above previous, background levels (Richerson et al. 2008).

There are numerous resources describing best management practices for road building, construction site, and farming practices to prevent surface erosion and landslides (Appendix A).

7.1.1 Erosion Hazard Analysis

Two erosion hazard analyses were carried out by NRCS personnel for the Middle Creek Watershed. The first was the potential for surface erosion in areas where the land surface has been disturbed, and the second was soil slippage risk. Details of the data and calculations used to generate the analysis and plates are included in Appendix B.

Surface erosion risk following disturbance (Plate 8) was determined assuming that disturbance activities have exposed 50-75% of the mineral soil surface. These activities could include forestry practices, grazing, mining, fire, firebreaks, etc. The analysis places soils in the following four categories: SLIGHT indicates that erosion is unlikely under ordinary climatic conditions; MODERATE indicates that some erosion is likely and that erosion-control measures may be needed; SEVERE indicates that erosion is very likely and that erosion-control measures, including re-vegetation of bare areas, are advised; and VERY SEVERE indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Soil slippage risk (Plate 9) is the possibility that a mass of soil will slip when these conditions are met: 1) vegetation is removed, 2) soil water is at or near saturation, and 3) other normal practices are applied. Other factors could increase the risk of soil slippage, but they are not considered here. Examples of these other factors are: 1) undercutting lower portions or loading the upper parts of a slope, or 2) altering the drainage or offsite water contribution to the site such as through irrigation.

Areas with severe and very severe erosion risk following land disturbance and with high soil slippage risk are concentrated on sloping grounds in the upper watershed, while level areas in the lower watershed have very low risk of erosion or soil slippage (Plates 8, 9).

7.2 Stream Channels

Stream channel form and stream processes tend to change from the headwaters of a stream, creek, or river to its mouth. The longitudinal profile of a stream from its headwaters to outlet can be divided into three zones (Figure 7-1). In Zone 1, the headwaters zone, the gradient, or slope of the stream is greatest. This zone is dominated by erosion of sediments which are transferred downstream. Zone 2, the transfer zone, receives some of the eroded material from Zone 1, and therefore usually has a floodplain and a meandering channel pattern. In Zone 3, the depositional zone, the stream gradient flattens to nearly level, and most eroded material is deposited. It is characterized by a broad, nearly flat valley with a meandering channel (NRCS 1998).

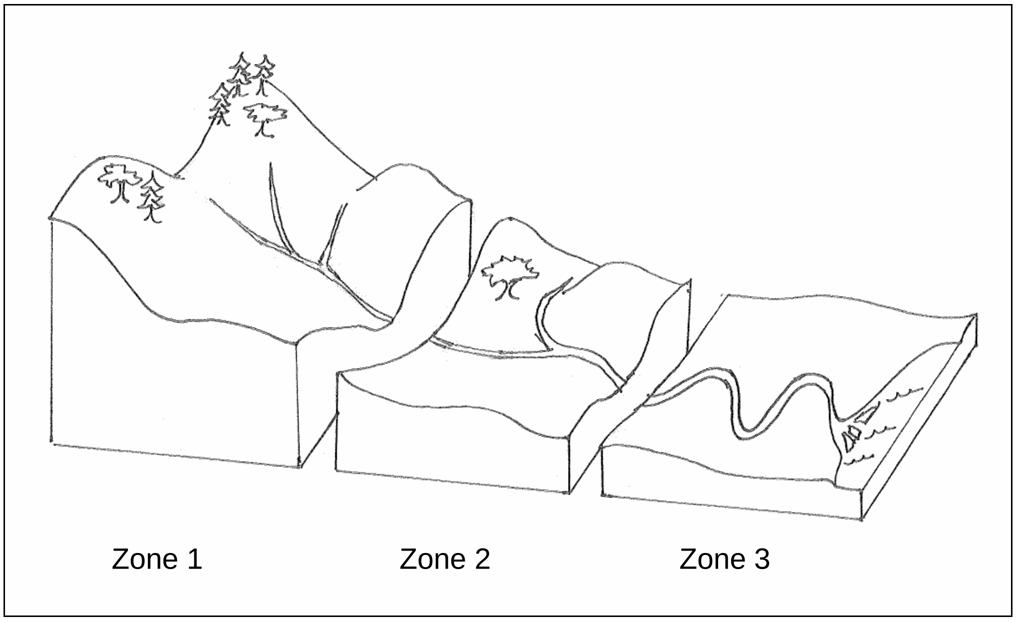


Figure 7-1 Longitudinal profile of a stream.

In Zone 1, stream size is typically small, and streams flow through v-shaped valleys with no floodplains. Therefore, the upland plant community is found adjacent to the stream. Where forests occur, they may form a canopy over the stream. Stream water temperatures tend to be relatively cold and stable due to groundwater recharge. Zone 2 has a wider channel and more complex floodplain than Zone 1. Plant communities adapted to periodic flooding are present in the floodplain. As the channel widens, the stream is exposed to more sunlight which causes larger daily water temperature fluctuations and an increase in the average water temperature. In Zone 3, large floodplain wetlands may be present because of the flatter terrain. In addition, valley hardwoods create productive and diverse riparian communities in the deep alluvial soils.

Stream channels often have a naturally occurring sinuous, or curving, channel form (Figure 7-2). Sinuosity tends to be low to moderate in Zones 1 and 2 and moderate to extremely sinuous in Zone 3. The sinuous pattern creates diverse aquatic habitats with an alternating series of pools at the bends of the watercourse and riffles (shallow, gravelly areas) in between the bends. The stream form is dynamic with the curves and channel migrating over the floodplain. This movement of the stream channel creates a diverse riparian community with older stages of vegetation on the outer curves, and new stages on the newly deposited point bars on the inside of the curves (NRCS 1998).

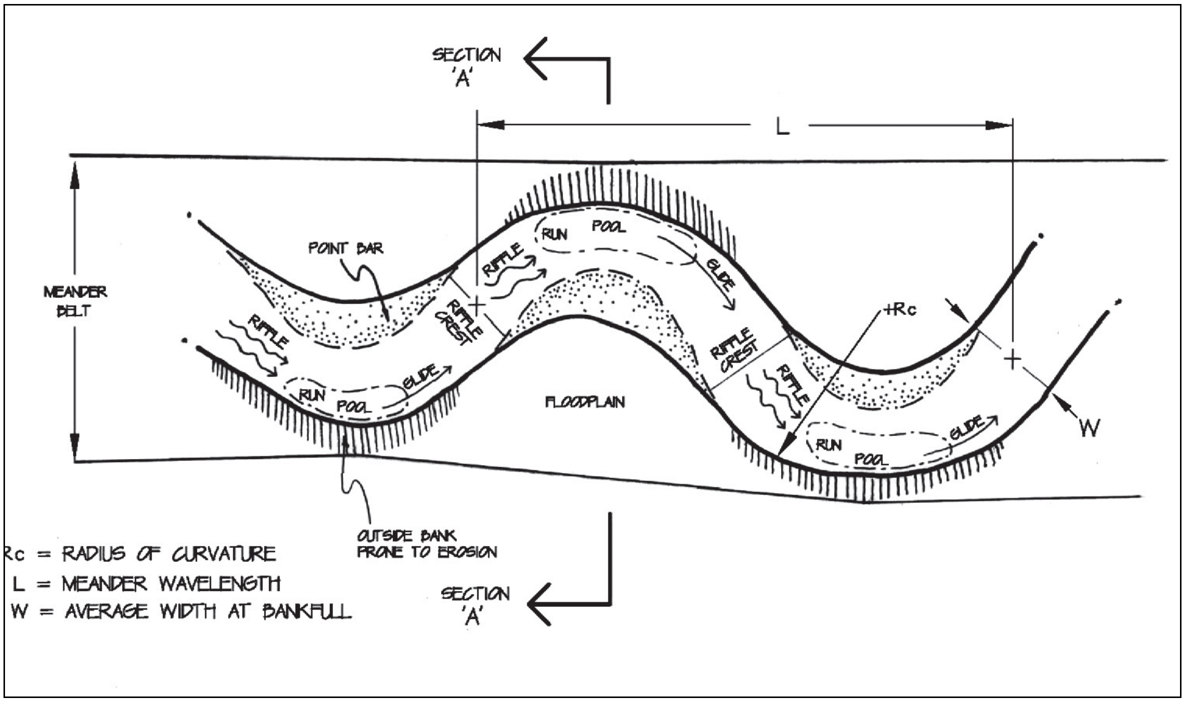


Figure 7-2 Stream pattern. *Figure courtesy of Marin Resource Conservation District, 2007.*

7.2.1 Activities Influencing Stream Channels

Many flood control practices alter stream channels and reduce habitat values for aquatic and terrestrial wildlife. Straightening and deepening, or channelization, of streams and rivers is often done for flood reduction and to “square up” agricultural fields and roads. Channel vegetation is also removed to increase water flow and prevent flooding. Straightening disrupts the pool and riffle sequences that are important components of aquatic habitat. Straightening reduces the length of a stream, although the overall change in elevation does not change. Therefore, it increases the stream gradient (slope) and the velocity of water moving through the stream channel. Increased water velocity in turn causes increased scouring and channel deepening. Construction of floodwalls and levees can increase stream velocity by constraining high flows to a narrower channel and allowing greater flood heights. Removal of large, woody debris for flood protection eliminates important aquatic habitat for fish and the aquatic insects on which they feed on (Leopold, L.B. 1997, NRCS 1998).

Water diversions for irrigation and other purposes reduce streamflows and may obstruct fish passage. Reduced water availability can have detrimental effects on water quality and aquatic organisms as discussed in Section 8.1.

In-stream gravel mining involves removal of vegetation, destruction of in-stream habitat, and alteration of the stream channel. Extensive gravel mining can lower stream channels with consequences for groundwater tables and recharge. Livestock are attracted to streams for water and often for shade. Their use of streams leads to loss of vegetation and increased streambank erosion, as well as potential fecal contamination of water. Off-highway vehicle (OHV) use of stream channels and the surrounding riparian areas damages streambank vegetation and contributes to streambank erosion.

Several land use activities have the potential to reduce soil permeability and water infiltration. During storm events, this leads to increased run-off, and more gradual water delivery through the soil profile to streams is reduced. Reduced soil permeability therefore leads to more "flashy" stream flows with higher flood peaks, greater erosion potential, and reduced sustained flows. Urban areas with impermeable surfaces contribute to flashy stream flows. Forestry, livestock grazing, and agricultural practices have the potential to reduce soil permeability, although management practices can lower or eliminate this potential.

7.2.2 Middle Creek Watershed Stream Channel Conditions

For the purposes of this assessment, the upper watershed is considered the steep, sloping portions of the watershed, and the lower watershed is comprised of the relatively level valleys.

Upper Watershed

Only very limited surveys of stream channel conditions in the upper Middle Creek Watershed were found for this assessment. A July 6, 1979 stream survey briefly described channel conditions of seven miles of the east fork of Middle Creek above the confluence to Middle Creek Flat (USFS 1980). The day and month when the stream survey was carried out were not indicated. The lower two miles were described as having "low, stagnant waters populated with rough fish, and partial to complete subsurface flow areas. ORV (OHV) travel is present in the dry channel, but it appears to be causing no harm to the stream" (USFS 1980). More detailed descriptions of "middle" and "upper" sections were given in this stream survey, but the length of these sections was not indicated. The middle section stream banks were described as steep and unstable with fresh debris in the channel from the previous winter. The stream gradient was 3%-5% in this middle section, watershed soil stability was described as stable, and the channel was described as unstable. In the upper section the stream gradient was 2%, and both the watershed soil and stream channel were described as stable. A description of timber harvest effects on the stream was given:

> "It appears that timber has been cut in the past. The new trees are well developed. Timber cutting has had an impact on this stream, mainly due to the slash left on the banks. There are frequent log jams with some deflecting the flow into the bank. Most of the upper bank has dense tree growth except in spots where logging has occurred. Debris flows are common on these logged slopes. Some pools have formed behind the log jams. I estimate the logging in this area has added about 25

points to the stability rating. Heavy vegetation is absent from the channel area" (USFS 1980).

The stability ratings mentioned in the above quote are from a USFS numerical stream evaluation. The stability ratings for the two sections were 96 and 101, indicating a "medium fair" rating. A lower number on the stability rating would indicate more stable conditions.

Stream channel evaluations were also conducted on Bear Creek, which rated as having "high good" stability (numerical rating 50), and Grizzly Canyon as having a "medium good" stability rating (numerical rating 61). These ratings were made on September 17, 1975.

Lower Watershed

Both Middle and Clover Creek channels in the lower portion of the watershed have been significantly modified beginning at the time of European settlement, and more significantly beginning in the 1920s. For the purposes of this assessment, the watershed boundary is drawn at the confluence of the original channel of Clover Creek with Middle Creek, however changes that were made below this confluence to Clear Lake are described for several reasons: (1) because they frequently affected upstream conditions, (2) because some projects occurred across the watershed boundary, and (3) because changes both above and below the boundary have an impact on Clear Lake water quality. Major modifications are listed in Table 7-2 and described in more detail below.

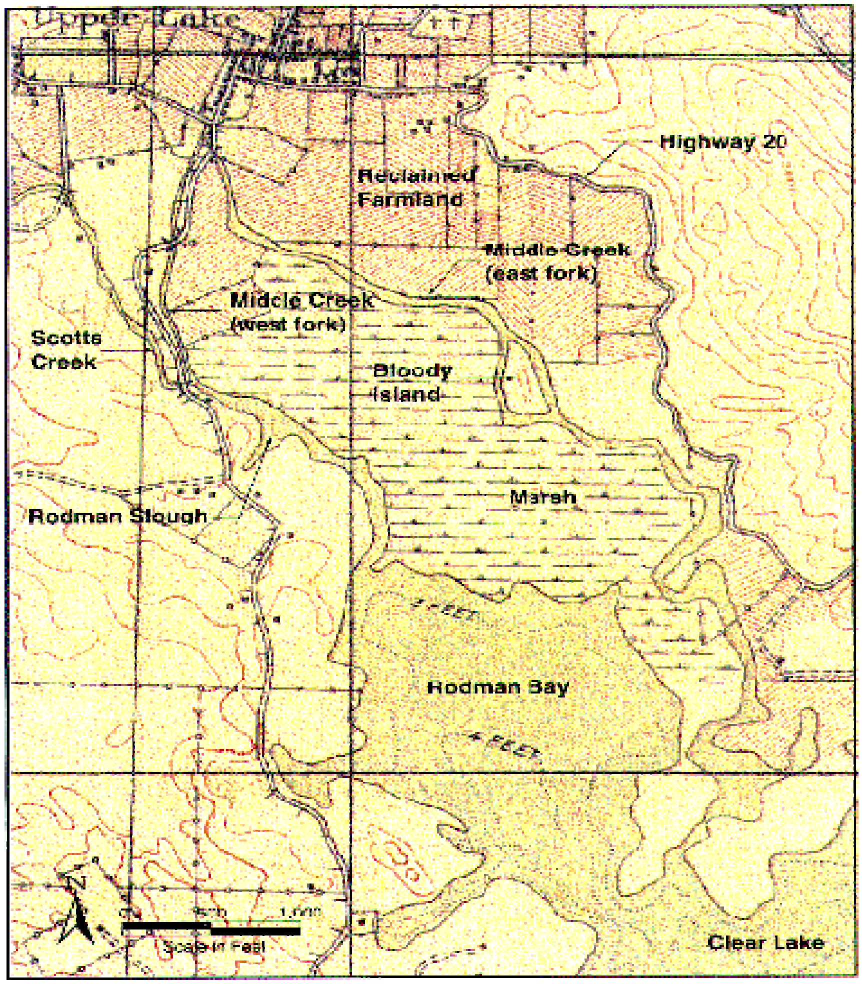
Table 7-2 Major modifications to Middle Creek and their time of occurrence.

Channel modifications	Time of occurrence
D.V. Thompson & J.M. Sleeper straightened Middle Creek west of Upper Lake.	Early 1800s
Gravel mining in channel. Most occured from mouth to confluence of east and west forks. Some in main portion of Clover Valley.	1800s to present
Middle and Clover Creeks re-routed from Hammond Slough to Rodman Slough.	1926
Formation of reclamation districts in Rodman Slough area.	1900-1933 (approx.)
Clover Creek diversion, flood control levees around Upper Lake built by USACE.	1959-1966
Concrete sill at Rancheria Bridge built by DWR.	1960-61
Limitations on gravel mining by Creek Management Plan.	1981
Significantly reduced in-channel gravel mining in Middle and Clover Creeks.	1992
Restoration projects from confluence to Hunter Bridge funded by a BIA grant to Robinson Rancheria.	2000-2002
Rock weirs installed below Rancheria Bridge to provide passage for Clear Lake hitch.	2005-2006
Clover Creek Diversion Weir modified to facilitate Clear Lake hitch migration.	2007

Prior to modification by settlers, the channel of Middle Creek in the vicinity of Upper Lake ran farther west, skirting the foot of Middle Mountain and joining Scotts Creek at the east end of Tule Lake (Sylar 1974). The combined flow of the creeks then branched into several channels in what is now the Reclamation Area and Rodman Slough area. The former locations of multiple, branching channels were apparent in 1940 and 1952 aerial photos (USACE 1997). Prior to European settlement, Clover Creek ran through the middle of what is now the town of Upper Lake, and south of town, ran around the north side of Bloody Island to join Hammond Slough and flow to Clear Lake. In the early 1800s settlers re-routed Middle Creek in the vicinity of Upper Lake to travel directly south. Although Sylar (1974) described Middle Creek as entering Clover Creek, a 1916 USGS map showed it branching into east and west forks, one of which joins Clover Creek, and one that flows south to join Rodman Slough (Figure 7-3).

Lands to the south of Upper Lake were reclaimed for agriculture beginning in about 1920. One of these areas was the Edmonds Reclamation District formed in 1926. As part of this project Clover and Middle Creeks were re-routed to their current locations, flowing south into Rodman Slough. The Edmonds Reclamation District was also required to significantly widen and deepen the creeks in order to maintain their status as navigable waters (Sailor 1959). This diversion, eliminating approximately 2000 acres of wetlands and routing Middle and Clover Creeks through the narrowly confined Rodman Slough is cited as one of the major earth moving activities leading to an approximate 10-fold increase in sedimentation rates to Clear Lake that began at this time (Richerson et al. 2008).

Further channelization of Middle Creek occurred when flood control levees and the Clover Creek Diversion Channel were built by USACE in the vicinity of Upper Lake in 1959-1966. Significant headcutting due to this project was observed almost immediately following a large Christmas week storm in 1964. A County report described excessive erosion and scouring to the banks, bottom, and levees throughout the project area above Highway 20 (LCFCWCD 1965). Stream bank erosion above the project area to Hunter Bridge was also documented, as was gravel accumulation behind the Clover Creek weir that blocked off flow to the old Clover Creek channel. As of 2009 approximately four feet of the bridge footings at Hunter Bridge are exposed, indicating that head-cutting has propagated upstream of the Bridge (Tom Smythe, personal communication).



Source: USGS Lakeport, California quadrangle 1924 (surveyed in 1916).

Figure 2.2
Historic Conditions of the Study Area, 1916

Figure 7-3 Creeks, wetlands, and Rodman Slough area in 1916. Note that the east and west fork of Middle Creek shown in this figure were in the Rodman Slough area and are no longer present.

Gravel mining in Middle Creek probably began when settlers first moved to the area in the 1800s. With the availability of heavy equipment, improved vehicles, and roads, gravel mining increased significantly by the late 1920s (Richerson, et al. 1994, LCPD 1992). Aggregate mined in stream channels was the main source of gravel in Lake County until the late 1980s (LCPD 1992).

Limitations on in-stream gravel mining in Lake County were first established with the Creek Management Plan (LCPD 1981). This plan prohibited gravel mining below 1 foot above the thalweg[12]. In 1992, the Lake County Aggregate Resource Management Plan (ARMP) prohibited in-channel gravel mining greater than 1,000 cubic yards in sensitive areas of the streams. These were the first 2.5 miles (Rodman Slough area) of Middle Creek, and from miles 5.87-6.7, the section above the flood control project up to the wide, gravel area below Hunter Bridge. At the same, time gravel mining was prohibited in Clover Valley from miles 0.71, the diversion structure, to 2.49, the gravel mined area in Clover Valley. Although not prohibited, in stream gravel mining was largely discontinued in other portions of lower Middle Creek by the early 1990s. Some gravel mining continues on terraces of the creek. This mining is visible as ponds in 2006 aerial photos (Appendix C).

Changes in stream vegetation and cover from the confluence of the east and west forks of Middle Creek to about one mile below Hunter Bridge due to gravel mining are not apparent from the aerial photo record, which begins in 1940. Comparison of aerial photos in 1940, 1952, 1970, and 2006 show a similar wide, braided, gravelly stream channel for the section of Middle Creek (Appendix C). However, close observation shows a lower stream bed, especially in the bend approximately 3/4 mile downstream of the Hunter Bridge. There, the stream bed has incised approximately 10 feet. Stream degradation in this area is likely to have been influenced by channelization downstream and upstream gravel mining. An obvious change in the aerial photo sequence is the appearance by 2006 of three large ponds in terraces along the floodplain of Middle Creek.

A series of restoration projects to stabilize streambanks and increase riparian vegetation, were carried out along the portion of Middle Creek from Hunter Bridge upstream to the confluence under a grant from the Bureau of Indian Affairs to Robinson Rancheria. Stream bank stabilization projects, using rock riprap and/or revegetaton with willow cuttings, were carried out at approximately ten sites. In addition, approximately ten sites along Elk Mountain Road, where culverts and drainage channels were causing accelerated erosion, were armored with rock rip rap.

In 2006 a series of “dragon’s teeth” weirs were installed along an eroding stream bank near the confluence of the east and west forks of Middle Creek to deflect streamflow from the bank. As of 2009, the weirs appear to be effective at stabilizing the bank in this area; however, downstream streambank erosion is still occurring, and the project needs to be expanded.

Four rock weirs were installed below the Rancheria Bridge in 2005, and the Clover Creek weir was modified in 2007 to improve passage of Clear Lake hitch (Section 6.2).

[12] The thalweg is the lowest portion of the stream channel.

The 1985 ARMP thoroughly documented stream channel conditions in the lower Middle Creek Watershed (LCPD 1992). The ARMP surveyed Middle Creek from its mouth at Clear Lake upstream to 1.65 miles past the confluence on the east fork, and 2.3 mile past the confluence on the west fork, Clover Creek for 4.3 miles above its mouth at the diversion channel, and 0.6 miles of Gilbert Creek. Stream channel conditions were described in sections that varied from a few tenths to approximately 5 miles in length. The length varied because sections were chosen to have similar conditions . Descriptions of stream bed and bank conditions, stream and stream bank vegetative cover, types of disturbance to the channel or stream banks, species present in the riparian plant community, adjacent land use, and fish potential were made for each section.

Following is an overview of 1985 lower Middle Creek stream channel conditions from the ARMP (LCPD 1992).

> “Middle Creek has been extensively modified since the turn of the century. While the Rodman Slough has retained much of its original character, it has been greatly reduced in size by the creation of dikes to create farm land.
>
> Approximately three miles of the creek (from Mile 2.5 to 5.8) was placed in an engineered flood control channel in 1958.
>
> While the mile of creek upstream from the flood control channel retains much of its original character, it is undergoing extensive downcutting and bank failure as the creek adjusts to damage upstream and downstream from this section.
>
> Upstream from Mile 6.7 (Mile 6.7 is about 1 mile below Hunter Bridge) the creek has undergone extensive damage to its bed and banks. This includes most of the six miles of channel extending up to Mile 12.7 on the east fork.
>
> In-channel mining has extended into banks and terraces for hundreds of feet. The channel is now shallow and braided and extends from 700 to 900 feet in width for much of its course. Major features such as in-channel islands have been removed.
>
> Ironically, part of the damage may be due to high gravel recharge rates caused by extensive erosion in the upper watershed. This erosion was due to fires and discontinued forestry techniques which allowed timber harvest along stream courses. The creek has meandered and cut its banks as channels have been filled by gravel” (LCPD 1992).

The ARMP describes the diversion channel, the first 0.71 miles of Clover Creek from the confluence with Middle Creek as "wide, flat and shallow." Vegetation is periodically removed by the county Flood Control District and the State Department of Water Resources" (LCPD 1992). From the diversion channel upstream to mile 2.45, where the stream takes an almost right angle turn to run along the base of the mountains east of Clover Valley, the creek is described as being in a relatively unmodified condition with a "dense valley foothill riparian community with a dense canopy and defined natural channel (deep, narrow, and meandering)" (LCPD 1992). Above this point, where the creek runs along the base of the mountains, the creek has

> "…undergone large-scale destabilization and channel widening in response to gravel extraction. While the channel ranges from 20 to 25 feet in width in the un-mined portions, it extends from 75 to 250 feet in width in the mined portions. As a result the channel has become shallow and braided and has lost the riparian forest from both banks. Levees have been constructed along the southwest bank in an attempt to reduce the loss of pasture." (LCPD 1992).

It should be noted that some of the differences between the section immediately above the diversion channel and the upper, gravel-mined section are due to differences in landscape position. The upper section is the first section of the stream to leave steep terrain and arrive in a level valley; therefore, deposition of rocks, gravel, and larger materials is expected there, while finer materials will be carried further down stream. The soil survey confirms this expectation. In the upper section, the soil map unit encompassing the creek and adjacent terraces to the south is classified as Xerofluvents-Riverwash complex. Xerofluvents are typically very sandy, gravelly soils formed on recently deposited alluvial materials. Riverwash consists of sand, gravel, cobbles, and stones in active stream channels. These soils are excessively drained and are unsuited to grazing because they support sparse stands of plants that rapidly deteriorate when overgrazed (SCS 1989). In contrast, the lower, un-mined section of creek runs through an area where the valley widens out, and soil types surrounding this section of the creek are Still and Lupoyoma loams. These soils consist of loam, silt loam, and/or clay loam to a depth of 70 inches or more. They are Class I agriculture soils supporting orchards, vineyards, hay, and pasture (SCS 1989). Clearly, this section of the creek would be less desirable for gravel mining, and would better support riparian vegetation when compared to the section above.

The 0.6 mile section of Gilbert Creek in the ARMP is described as having a relatively brief, seasonal flow, running through dry annual grassland, lacking woody vegetation, and remaining in a fairly natural condition (LCPD 1992). This section of Gilbert Creek is mapped in the soil survey as Xerofluvents-Riverwash complex (SCS 1989).

The MCCRMP carried out detailed "Greenline" surveys of lower portions of Middle Creek in 2005 and 2006 (Figure 7-4), and MCCRMP member Sunny Franson wrote reports summarizing the surveys (Franson 2005, Franson 2006). Surveys were carried out in June and July of 2005, and Middle Creek was surveyed from Rancheria Bridge to Hunter Bridge and upstream of Hunter Bridge. In 2006, one survey was carried out from Rancheria Bridge to Hunter Bridge. These surveys included GPS coordinates of the area surveyed, descriptions of channel vegetation and the plant community within one kilometer, descriptions of stream bed and bank conditions, and wildlife observed. The summary of the surveys noted that very different conditions were found north and south of Hunter Bridge. The 2005 surveys documented the different plant communities along the stream channel north and south of the bridge. In addition, a greater number of bird species was observed south than north of Hunter Bridge. Bird numbers were greater south of Hunter Bridge primarily due to a colony of Cliff swallows at Rancheria Bridge.

Figure 7-4 Volunteers begin the creek survey above Rancheria Bridge on July 9, 2006. *Photo Courtesy of Middle Creek CRMP*

7.3 Flooding and Floodplain Management

Flood zones are mapped by the Federal Emergency Management Agency (FEMA) as part of the National Flood Insurance Program (NFIP), and 1% and 0.2% annual chance flood zones in the Middle Creek Watershed are shown in Plate 10. The 1% annual chance flood zone means that there is an estimated one percent chance of a flood of that magnitude in any given year. A common way of referring to the 1% annual chance flood zone is the 100 year flood zone, because on average, a flood occurs once every 100 years in this zone.

On average, a flood would occur once every 500 years in the 0.2% annual chance flood zone. Flood Zone D is the area of undetermined flood hazard, and flood Zone X is an area with 0.2% annual chance flood or 1% annual chance flood with less than one foot water depth.

Prior to the USACE Middle Creek Project from 1959-1966, significant flooding occurred in the town of Upper Lake on several occasions in the 1900s (Figures 3-1 and 3-2). The flood control levees built by the USACE were designed to protect the surrounding area from the 0.5% annual chance flood (200 year flood) in Middle and Clover Creeks (Figure 7-5). The design of the project has not eliminated flooding in the town of Upper Lake, however. Following the New Year's Eve flood of 2005 the lower (southern) portion of the town of Upper Lake experienced significant flooding. This flooding occurred because surface run-off from precipitation falling outside the levees backs up north of the levees where Middle Creek and the original channel of Clover Creek join. This happens when flap gates, designed to allow water coming from the north to pass through the levee and enter Middle Creek, are prevented from opening by high flows in Middle Creek. This same problem occurs in the area north of the junctions of Scotts and Middle Creeks immediately adjacent to the Middle Creek Watershed. The News Year's Eve flood of 2005 caused flood waters approximately in the vicinity of the intersection of Highway 20 and Main Street in Upper Lake.

Operation and maintenance of the Middle Creek Flood Control Project above the confluence of Middle and Scotts Creeks is conducted by the Lake County Watershed Protection District (LCWPD) as County Flood Control Zone 8 (Section 16.5).

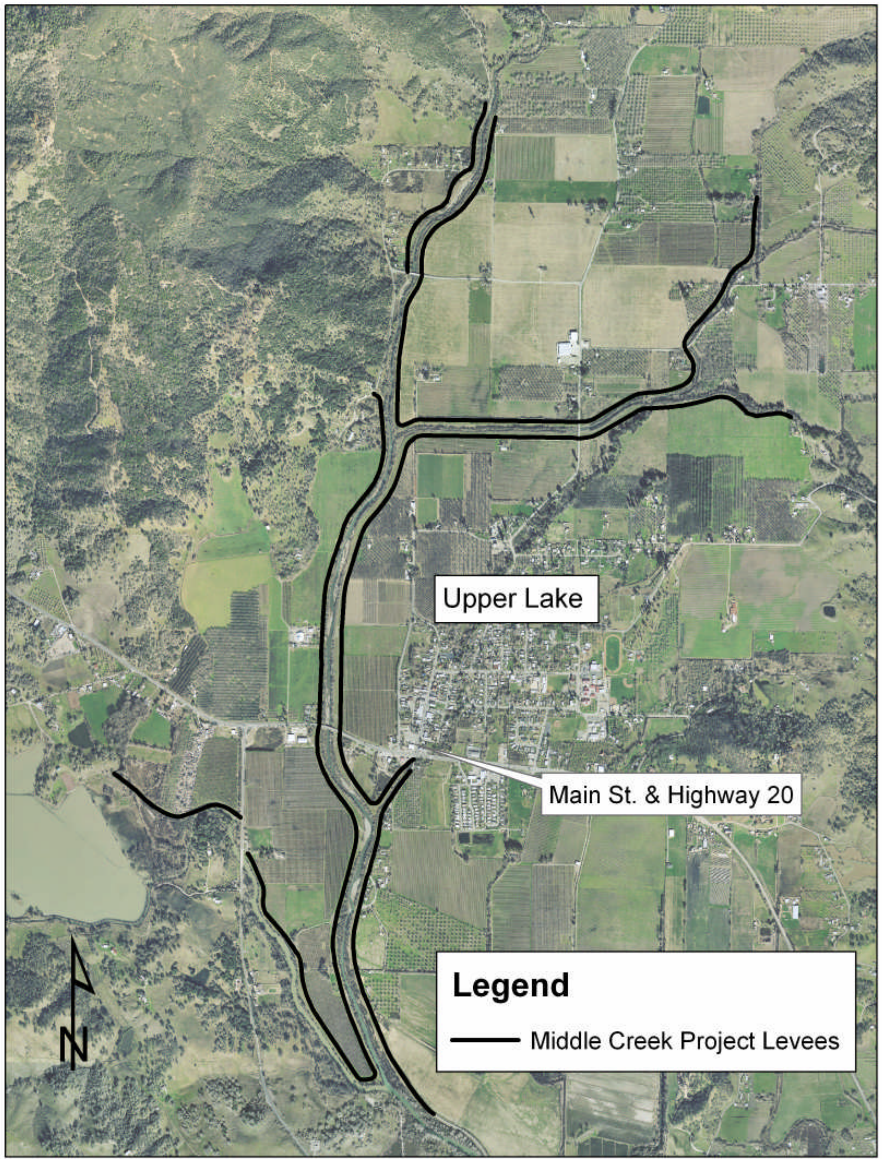


Figure 7-5 Location of USACE Middle Creek Project Levees.

7.3.1 Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project)

Since 1995, the LCWPD has been pursuing the Middle Creek Project, a project to acquire 1,650 acres of reclaimed land adjacent to and south of the Middle Creek Watershed to restore it to wetlands. This project has been identified as the single largest recommended water quality improvement to Clear Lake. It would restore the largest damaged wetland area around the lake, and the restored wetlands would filter water from the Scotts Creek and Middle Creek Watersheds, which contribute an estimated 57% of the inflow and 71% of the phosphorus loading to Clear Lake (USACE 1997). The USACE estimates that phosphorus and sediment inputs from Scotts and Middle Creeks would be reduced 40% by the Middle Creek Project, which amounts to an estimated 28% reduction for Clear Lake as a whole. (See Section 8.3) Eighteen homes and a large area of agricultural land would be purchased as part of the Middle Creek project, and the homes would be removed. These properties would therefore no longer be subject to the economic risk of flooding. The Middle Creek Project would also restore approximately 1,400 acres of wetlands, provide valuable fish and wildlife habitat, and increase the current area of wetlands around Clear Lake by 73% (Figure 7-6).

The USACE completed a feasibility study and environmental documentation (EIS and EIR) for the study in 2002. The Lake County Watershed Protection District (LCWPD) has received $5.714 million in grants from DWR to begin land acquisition in the area, and as of December 2007, 134 acres have been acquired (CLTSC 2008, LCWPD 2007). In November 2007, authorization for the USACE to participate in the Middle Creek Project was passed as part of the Federal Water Resources Development Act. Additional federal legislation appropriating money for the project and transferring the "USA In Trust" properties (held in trust for the Robinson Rancheria Band of Pomo Indians) outside of the project boundaries are required. The Lake County Board of Supervisors, the LCWPD and the Robinson Rancheria have been lobbying federal representatives to pass this legislation. California Assembly Bill 74, authorizing state participation in the Middle Creek Project passed in October 2009.

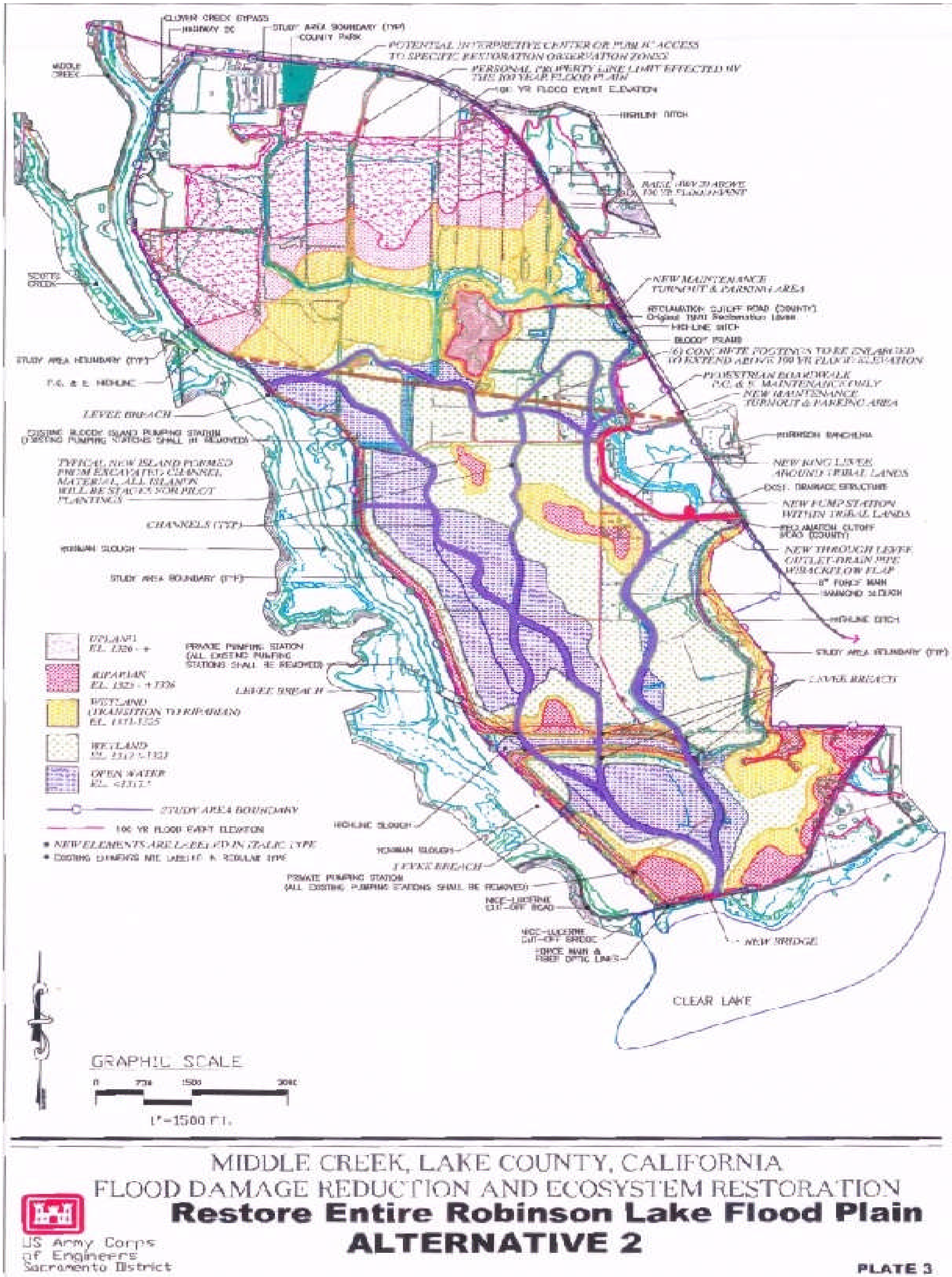


Figure 7-6 Map of proposed Middle Creek Project. Alternative 2 is the project alternative chosen to be pursued in the Feasibility Study/Environmental Impact Report (USACE 2002).

8.0 Water Quality

8.1 Stream Water Quality

Physical, chemical, and biological stream characteristics are expected to be inherently different in the upper and lower portions of the watershed. In the upper watershed are cold, rapid flowing streams suitable for trout. Rapid streamflow helps maintain lower water temperatures and higher dissolved oxygen levels. Rapid flows also help to flush organic materials, sediment, and nutrients that contribute to bacterial, algal and plant growth, and high biological oxygen demand. In general, headwater streams have lower concentrations of dissolved chemical compounds than streams lower in a watershed because evaporation causes the chemicals to become more concentrated lower in the watershed (Harrington, J. and M. Born 2000). In the lower watershed, the stream gradient is more gradual, and flows are slower leading to warmer conditions suitable for warm water fish species.

Human activities have the potential to alter stream conditions, frequently in ways that harm aquatic ecosystems. Activities such as livestock grazing, construction, and agriculture contribute increased sediment loads to streams. Although suspended sediment can harm fish directly, the greatest harm to aquatic ecosystems comes from deposition of sediment on the stream substrate. Sediment fills in gravel needed for spawning and smothers the habitat needed by insects and other organisms that are the food source for fish (Harrington, J. and M. Born 2000).

Nutrient sources such as sediment, animal waste, sewage, and fertilizer stimulate algae and plant growth in a process called eutrophication. Eutrophication decreases the diversity of aquatic life because organisms that function as collectors and filterers come to dominate the food web. When the large amounts of biomass produced by eutrophication begin to decompose, dissolved oxygen levels drop and cause die-offs. Eutrophication also increases turbidity or cloudiness of the water (Harrington, J. and M. Born 2000).

There are numerous toxic pollutants that can enter streams from industrial, agricultural, urban, or municipal wastewater sources. These include metals, such as mercury, lead, or copper; organic compounds, such as petroleum and many pesticides; anions, such as fluoride and cyanide; acids and alkalis that affect the pH of water; and gases, such as chlorine and ammonia (Harrington, J. and M. Born 2000).

Temperatures are altered by removal of tree canopy or alteration of the streamflow regime. The maximum amount of oxygen that can be dissolved in warm water is lower than that in cold water. Biological activity also speeds up with increasing temperature; therefore, oxygen supplies can be depleted more rapidly as water temperature increases.

Reduced streamflows due to lower ground water tables and water diversions contribute to the water quality problems discussed above by increasing contaminant concentrations and raising water temperatures.

8.1.1 Studies on Middle Creek Upper Watershed

There have been no recent surveys of stream water quality in upper portions of the watershed. However, qualitative observations of stream conditions near the confluence indicate that there are greater sediment loads coming from the east than west fork of Middle Creek. For about the past five years, during the "Kids in the Creek" event in May, Lee Morgan, MNF Fisheries Biologist, has observed the lower portions of the east and west Forks of Middle Creek near their confluence at the Middle Creek Campground. Additionally in one past year, he looked farther upstream on the east fork to where the stream gradients start to climb. This reach is upstream of direct effects of the OHV trail system. On the east fork, he has observed greater fine sediments in pools and lower abundance and diversity of aquatic macroinvertebrates compared to the west fork (Lee Morgan, personal communication). Potential causes of increased sediment loads, if they are verified for the east fork of Middle Creek, could be from continuing effects from timber harvesting and/or the 1996 Fork Fire, OHV trails and use, roads, or naturally higher rates of soil erosion. The Fork Fire burned nearly all of the east fork of Middle Creek sub-watershed in 1996, while the most recent large fire on the West Fork of Middle Creek Watershed, the Round Fire, occurred in 1960, and burned only on the north side of the creek (Plate 11). The distribution of roads in the Middle Creek Watershed is shown in Plate 7.

Lower Watershed

The biggest emphasis of water quality studies on Middle Creek has been on nutrients and sediment because these constituents contribute to impaired water quality in Clear Lake. Although the water quality sampling is carried out in the lower watershed (at the DWR gage located at the Rancheria Bridge, Plate 3), much of the sediment is likely to be coming from the upper watershed.

Because of nuisance algal blooms caused by excess nutrients, Clear Lake was identified as impaired due to nutrients in 1986 under Section 303(d) of the Federal Clean Water Act. This required the Central Valley Regional Water Quality Control Board (CVRWQCB) to establish a Total Maximum Daily Load (TMDL) program to manage the pollutant and ensure the beneficial uses of Clear Lake (CVRWQCB 2006). Clear Lake is also on the federal 303(d) list for mercury, and the TMDL for Control of Mercury in Clear Lake was approved in December 2002. Sediment is considered to be the primary source of excess nutrients in Clear Lake. The Sulphur Bank Mercury Mine is considered to be the major source of mercury entering Clear Lake, however, some mercury comes from the surrounding watershed, primarily in sediment-bound form.

Samples were taken near the permanent stream gages to determine a relationship between streamflow rate (discharge) and the amount of sediment or nutrients suspended in the water. Because of the great variability of rainfall patterns in California, it is necessary to continue these studies over many years (Florsheim J. 2007). The studies were also continued in order to find out whether nutrient and sediment transport is changing due to changing land management practices.

As part of a UC Davis study, water was sampled during the winters of 1991-1992 and 1992-1993 at the DWR gages on Kelsey, Scotts, and Middle Creeks. Although the number of samples in this study was small, (7, 6 and 6 for Kelsey, Middle and Scotts Creeks, respectively) the information was used to estimate phosphorous and sediment inputs to Clear Lake (Richerson et al. 1994). LCPWD carried out further sampling on Kelsey, Scotts, and Middle Creeks from 1993-1998. Parameters measured were temperature, pH, conductivity, total solids, dissolved solids, orthophosphate, and total phosphorus. As part of a Clear Lake watershed TMDL Monitoring Program, additional sampling was carried out in 2007-2008, for mercury, methyl mercury, chloride, sulfate, and iron as well as the parameters measured from 1993-1998. The 2007-2008 total suspended solids and total phosphorus data for Middle Creek are shown below in Figures 8-1 and 8-2. In all cases, the sampling studies found that the concentrations of sediment (total suspended solids) and phosphorus increased as streamflows increased.

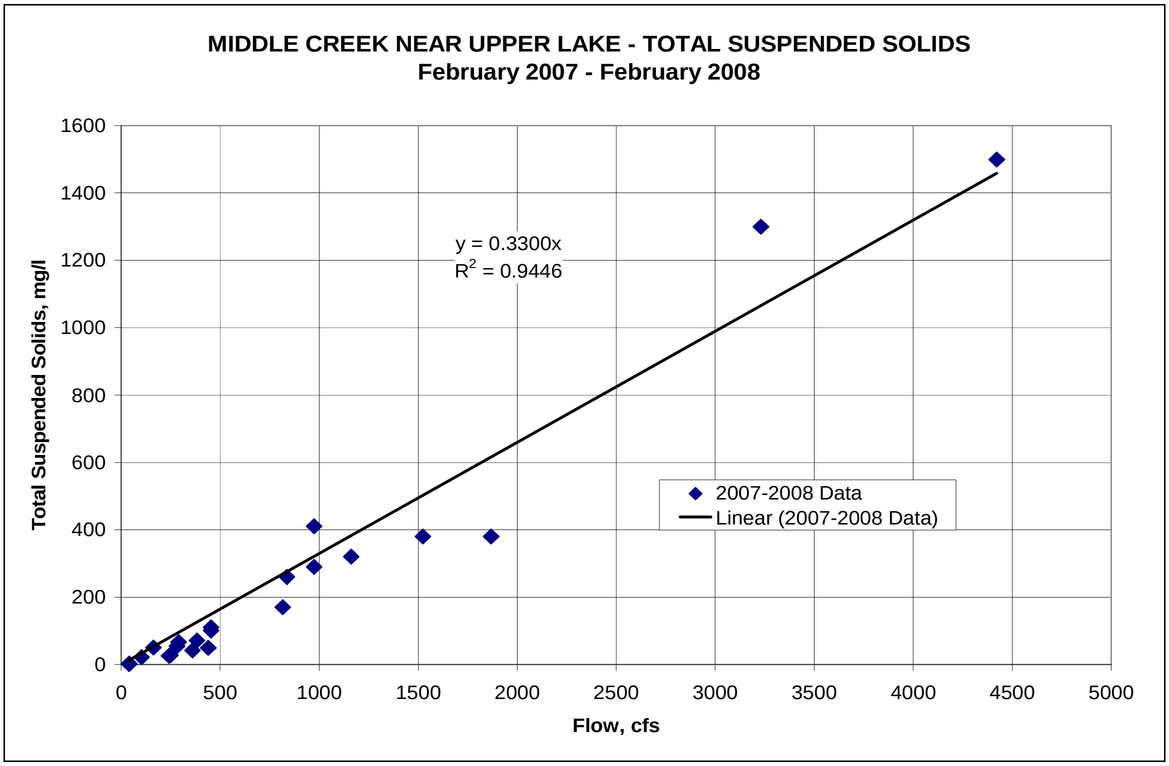


Figure 8-1 Relationship between sediment and streamflow in Middle Creek. *Source: LCPWD, Water Resources Division.*

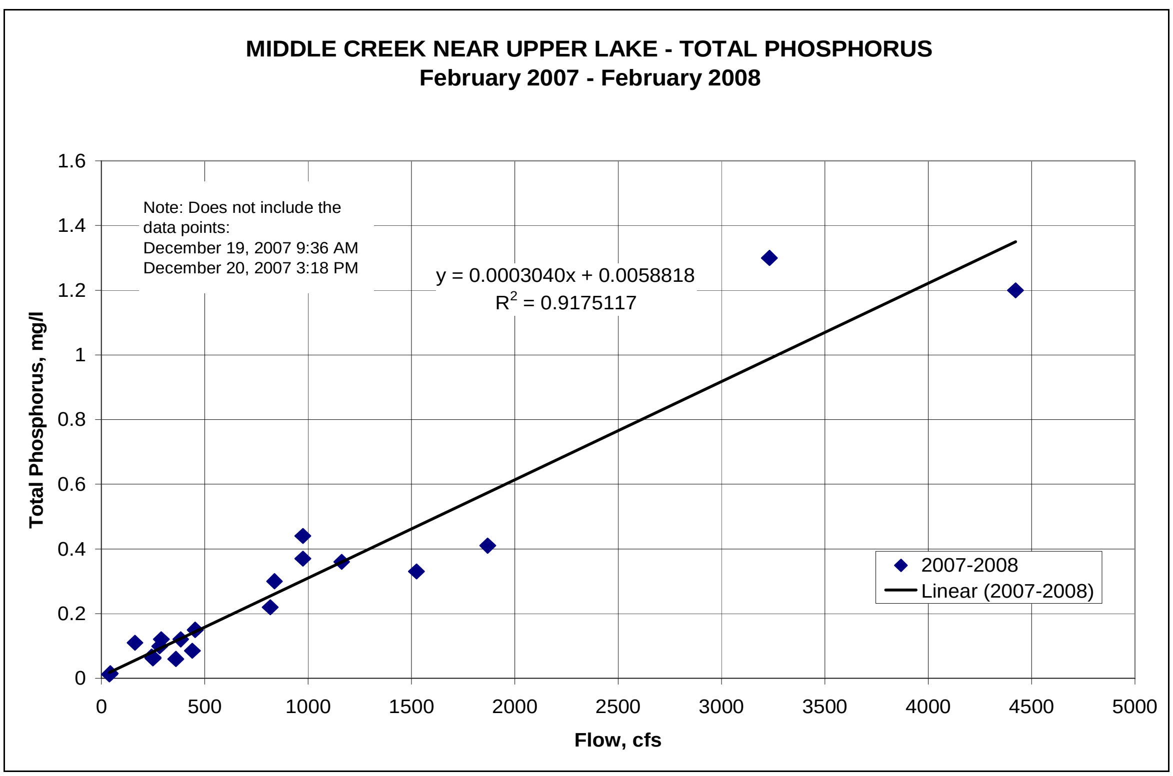


Figure 8-2 Relationship between total phosphorus and streamflow in Middle Creek. *Source: LCPWD, Water Resources Division.*

The total and methyl-mercury mercury sampling conducted during 2007-2008, showed similar patterns to sediment and phosphorus. These constituents also increased with increasing flow. To look for the presence of mercury 'hotspots' in the upper watershed additional sampling of sediments for mercury was conducted in Middle Creek near the confluence of the East and West Forks, however no elevated levels were detected.

Local volunteer water quality monitoring teams, "stream teams" monitored stream health with stream bioassessments from 2004-2006. Using relatively simple physical and chemical measurements, as well as a biological component, their objective was to gage the ecological health of local stream systems. The advantage to this approach is that "biological and physical assessments are substantially less expensive than chemical and toxicological testing, integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality, and provide the public with more familiar expressions of ecological health" (SLSII 1999). With grant funding from the 319h federal non-point source pollution program, local watershed groups provided training workshops and guidance for the volunteers.

The volunteer groups measured streamflow, temperature, dissolved oxygen, pH, conductivity, and turbidity. They sampled and identified benthic macroinvertebrates[13] and made visual observations of stream conditions using the California Stream Bioassessment Procedure in Middle Creek on July 5, 2005 and June 25, 2006. The sampling was conducted just downstream of where the Clover Creek diversion channel enters Middle Creek. Bioassessment results gave this location in Middle Creek a rating of poor based on a Russian River Watershed Index. Complete results for the sample are in Appendix D.

Pesticide monitoring on creeks in Lake County has been carried out since 2005 to comply with the state Irrigated Lands Regulatory Program. Most owners of irrigated agricultural lands in Lake County have joined the Sacramento Valley Water Quality Coalition, which is managing the monitoring program. Monitoring was initiated in the Lake County area with the heaviest concentration of agriculture, Big Valley, and after two years it was shifted to Middle Creek. Monitoring includes water and sediment toxicity tests, physical water quality parameters, and levels of pesticides, metals, and nutrients.

[13] The benthic zone is the substrate below a body of water. Benthic macroinvertebrates are "animals without backbones that are larger than ½ millimeter (the size of a pencil dot)." They include "crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs" (MDNR 2004).

In Middle Creek, one sampling event was conducted in the winter of 2006-2007 on February 9, 2007. Simazine, an herbicide, was detected at levels well below the California primary drinking water standard. DDT was detected at levels above the California Toxics Rule criteria (SVWQC 2007). DDT is a "legacy" pesticide that has been banned for use in the United States since 1972. It is very persistent and binds to soil; therefore, its detection may have been due to soil disturbance. Recommendations for controlling agricultural sources of DDT are to promote cultural practices that minimize soil erosion and sediment transport from agricultural lands. Two samples were taken on Middle Creek during the following winter on December 20, 2007, and January 29, 2008, and no pesticides or toxicity were detected (SVWQC 2008).

Illegal marijuana gardens are an increasingly common problem, frequently on public lands. These operations may cause water pollution with fertilizer, diesel, and other chemicals (Section 15.3).

8.2 Groundwater Quality

Groundwater quality depends on the quality of water that recharges the aquifers, the chemical properties of the aquifer matrix, and natural or human inputs such as fertilizer and pesticides, septic system leachate, or waste disposal area leachate.

DWR samples well water periodically for a range of minerals, nutrients, and physical measurements such as electrical conductivity. A summary of the available DWR groundwater data from the Upper Lake basin from 1945-2000 is given in Table 8-1. When measured, levels exceeded primary or secondary drinking water or agricultural standards, the number and range of exceedances is reported. The total number of samples that were taken is also reported.

Primary drinking water standards are legally enforceable standards to protect public health. They apply to public water systems. Secondary drinking water standards are nonenforceable guidelines that regulate contaminants that may cause aesthetic or cosmetic affects (USEPA 2009). Both California and the Federal Government establish drinking water standards, and California standards are sometimes more stringent than the federal standards. The agricultural standards are based on a report by the United Nations Food and Agriculture Organization (Ayers 1985) as quoted in the CVRWQCB Water Quality Goals (CVRWQCB 2008).

Table 8-1 Upper Lake groundwater basin chemistry, electrical conductivity, and pH, measured by DWR from 1945-2000.

Constituent	Average (Concentration in mg/L unless noted)	Number of Samples	Number of Exceedances	Range of Exceedance (Concentration in mg/L unless noted)	Exceedance type and limit*
Alkalinity	1351	168			
Aluminum	0.011	3			
Arsenic	0.0046	15	2	0.024-0.033	Primary Drinking Water Standard 0.01 mg/L
Barium	0.8612	6	1	4.4	Primary Drinking Water Standard 1.0 mg/L
Boron	3.02	140	10	0.8-79.0	Agriculture, 0.70 mg/L
Cadmium	0.0035	8			
Calcium (dissolved)	30.42	139			
Chloride	32.32	184	12	111-600	Secondary Drinking Water Standard, 250 mg/L, Agriculture 106 mg/L
Chromium	0.0035	13			
Copper	0.0033	15			
Electrical Conductivity (field)	461 (micromhos)	29	3	1072-1232	Secondary Drinking Water Standard, 900 micromhos, Agriculture 700 micromhos
Fluoride	0.38	65			
Iron	0.8214	12	4	1.41-3.96	Secondary Drinking Water Standard, 0.3 mg/L
Lead	0.0035	15			
Magnesium	19.57	138			
Manganese	0.2685	15	8	0.06-0.92	Secondary Drinking Water Standard, 0.05 mg/L
Mercury	0.0003	6			
Nickel	0.0023	3			
pH (field)	6.9 pH units	29	2	6.2	Secondary Drinking Water Standard and Agriculture, less than 6.5 or greater than 8.5
Potassium	1.1	121			
Selenium	0.0024	8			
Silicon Dioxide	24.26	61			
Sodium	34.17	170	14	70-460	Agriculture, 69 mg/L
Sulfate	21	13			
Total Dissolved Solids	219.67	58			
Turbidity	19 (NTU)	3	3	1.5-40	Primary Drinking Water Standard, 1-5 NTU
Zinc	0.1086	15			

**Source CVRWQCB 2008.*

There were six exceedances of primary drinking water standards, indicating that it is advisable for landowners with private wells to have their water tested. All three samples for turbidity exceeded primary drinking water standards, however it is likely that filtration would lower the turbidity readings. It is unknown whether turbidity was sampled on wells likely to have this problem, or whether turbidity is a widespread phenomenon in the Upper Lake groundwater basin. Sampling for most of the constituents was quite limited considering that the table includes all the samples reported by DWR from 1945-2000. More recent data from DWR were not available at the time of this report, if they exist. The potential for agricultural water quality exceedances, for example high boron levels, indicates the need for testing water prior to investment in agricultural operations.

Not reported in Table 8-1, are DWR measurements of nitrogen containing compounds such as ammonia, ammonium, nitrate and nitrite. These are not reported because DWR reporting of the units of measurement (as nitrogen or the entire compound) was not consistent or clear over the 1945-2000 time period. Fertilizer use, areas where livestock are concentrated and septic systems may lead to increased levels of nitrogen-containing compounds in groundwater, and high levels of nitrate and nitrite can be harmful to human health. Due to the problem with reported units, however, it was not possible to determine whether there were any drinking water standard exceedances.

8.3 Clear Lake Water Quality

Clear Lake is listed as an impaired water body under the Clean Water Act Section 303(d) for nutrients and mercury. As discussed below, the major source of nutrients to Clear Lake is considered to be sediments from the surrounding watershed. Sediments also contribute to mercury pollution, although they are unlikely to be a major contributing factor.

Nutrients, Algae and Plants

Clear Lake is naturally eutrophic (high in nutrients, algae, and plant growth), and studies of lake sediment cores indicate that it has supported abundant algal populations for most of its history (Sims *et al.* 1988). Because Clear Lake has abundant algae and plant life, it supports large invertebrate and fish populations in the lake, which in turn feed water fowl and other animals that live around the lake.

Although it is not likely that Clear Lake was ever "crystal clear", it was apparently relatively clear prior to major impacts from land use activities of European settlers. Sediment cores indicate that sedimentation rates to the lake increased dramatically in about 1930 as heavy earth-moving equipment became available (Richerson et al. 1994, 2000, 2008). By 1938, severe blue-green algal blooms and insufficient water transparency for rooted aquatic plant growth were documented (Richerson et al. 2000). Starting in the 1990s, water clarity improved, and rooted aquatic plants increased in Clear Lake. In the summer of 2009; however, a prolonged and severe blue-green algae bloom of the genus *Lyngbya* occurred.

Suspended algae, the tiny photosynthetic organisms floating in the water column in Clear Lake include numerous species of green algae, diatoms, flagellates, and blue-green algae. Blue-green algae, or cyanobacteria, are bacteria with the capacity for photosynthesis, and they create the most noxious algal blooms. When severe blue-green algae blooms occur "the water becomes completely opaque, and the scums resemble thick olive drab paint covering entire beaches and sometimes creating patches thousands of square meters in size in open water" (Richerson et al. 1994).

The noxious algal blooms prompted Lake County to seek funding for two major research efforts. The Clear Lake Algal Research Unit, directed by Alexander J. Horne from 1969 to 1976, and the Clean Lakes Study and Clear Lake Environmental Research Center, headed by Peter J. Richerson and Thomas H. Suchanek from 1991 to 2002, investigated the causes and potential controls of nuisance algal blooms.

The researchers focused on what mineral elements are contributing to the high algal biomass. They found that Clear Lake has high phosphorus availability and most of this phosphorus is transported into the lake attached to sediments. Desirable forms of algae do not grow to high levels because they do not have sufficient nitrogen in the forms they require (nitrate and ammonium). Several common species of blue-green algae, however, can use nitrogen gas present in the atmosphere, and therefore can grow to high levels when phosphorus availability is high. Researchers also found evidence that growth of blue-green algae was sometimes limited by the availability of iron. The main source of iron entering the lake is also in sediments.

Because of nuisance algal blooms caused by excess nutrients, Clear Lake was identified as impaired due to nutrients in 1986 under Section 303(d) of the Federal Clean Water Act. This required the CVRWQCB to establish a Total Maximum Daily Load (TMDL) program to manage the pollutant and ensure the beneficial uses of Clear Lake (CVRWQCB 2006). The nutrient TMDL sets a numeric target for algae levels based on the amount of chlorophyll a, a pigment found in algae. It also mandates a phosphorus load reduction of 40% in order to achieve water quality objectives.

Although the reason for the improvement is not understood, beginning in the 1990s, lake transparency improved and submerged aquatic plant growth increased. The plant growth created congested conditions along the shoreline that restricted swimming, boating, and other recreational activities. Lake County developed an Integrated Aquatic Plant Management Plan in 2005 to support continued multiple uses of Clear Lake, identify environmentally sound and cost effective management approaches, and avoid adverse impacts on humans and non-target plants and animals (Jones & Stokes 2005). Lake County now manages a permit program for aquatic weed control that includes monitoring to insure the proper use of aquatic herbicides and monitor for their fate. Monitoring thus far has shown that herbicides are undetectable one week after application.

Mercury

Mercury is a significant contaminant of Clear Lake waters; however, it is likely that the Middle Creek Watershed is a minor source of mercury. The CVRWQCB estimates that the Sulphur Bank Mine, an open pit mine located on the east end of the Oaks Arm, contributes approximately 97% of the mercury to the lake (CVRWQCB 2002). In 1987, the California Department of Health Services issued an advisory recommending limited consumption of fish from Clear Lake due to elevated mercury levels. Based on this advisory, the CVRWQCB placed Clear Lake on the Federal Clean Water Act 303(d) list of impaired water bodies in 1988, thereby requiring a TMDL program, and the TMDL for Control of Mercury in Clear Lake was approved in December 2002.

As part of the mercury TMDL requirements, the LCWPD began monitoring for mercury “hot spots” throughout the Clear Lake watershed in 2006. Both water and sediment samples were collected from streams to determine background levels for sub-watersheds such as Middle Creek. Sampling was completed in 2008, and a total of 23 samples were taken in the Middle Creek Watershed. No elevated mercury levels were found in the Middle Creek Watershed (LCWPD 2009).

Aquatic Pesticides

Pesticides applied directly to Clear Lake affect the adjacent watershed through effects on fish and wildlife that inhabit both places. Pesticides were applied to Clear Lake in the past to control the Clear Lake gnat (*Chaoborus astictopus*) and currently to control aquatic weeds. The effort to control the gnat by chemical means was perhaps the “most serious single” human disturbance to the Clear Lake system (Richerson, P.J. and S.O. Richerson 2000) and gave Clear Lake the unfortunate distinction of being included in Rachel Carson’s environmental classic, Silent Spring (1962). The Clear Lake gnat, whose larvae live in the lake feeding on tiny crustaceans, once emerged as adults in huge numbers. Although the gnats do not bite, they were present in such numbers as to present a nuisance. “Old-timers claim they sometimes accumulated under streetlights in Lakeport to depths of 3 feet” (Richerson, P.J. and S.O. Richerson 2000). After three lakewide applications of DDD to control the gnats in 1949, 1954 and 1957, the population of western grebes in Clear Lake nearly collapsed. Other pesticides were used to attempt to control the gnat, but it appears that biological control by the Mississippi silversides, a fish introduced in 1967, has permanently reduced gnat populations (Richerson, P.H. and S.O. Richerson 2000).

Aquatic herbicides are currently used to control *Hydrilla verticillata*, an aggressive, non-native aquatic plant found in Clear Lake in 1994. Immediately after its discovery, the California Department of Food and Agriculture (CDFA) began a hydrilla monitoring and eradication program in Clear Lake because if left uncontrolled, hydrilla could fill the water body, preventing boating and clogging water intakes. Mechanical weed control spreads hydrilla, so chemical control is required. Herbicides are also used by lakefront property owners to control aquatic weeds. Herbicide use by both CDFA and private property owners requires use permits and pesticide fate monitoring.

9.0 Water Supply

Surface water supplies in the Middle Creek Watershed are limited to creeks and streams. The only groundwater supply in the watershed that has been studied is the Upper Lake aquifer. Total groundwater storage in the Upper Lake aquifer is estimated to be about 12,000 acre-feet, and usable storage is estimated to be 7,600 acre feet (Section 6.5).

Water use in the Middle Creek Watershed was determined as part of the Lake County Water Inventory and Analysis (LCWIA), which used the year 2000 to represent a year with average precipitation (CDM and DWR 2006c). Agricultural water use accounted for 94% of the total water use in the watershed. Municipal and industrial use including residential, commercial, industrial, and institutional water use accounted for only 3.5% (Table 9-1). Conveyance losses were 2.5% of total water use. The water use estimated in the LCWIA includes the Rodman Slough area south of Highway 20. There is significant agricultural water use in this area for rice, irrigated pasture, and wine grapes. While total adjusted water use shown in Table 9-1 appears to be about equal to the safe groundwater yield in Table 7-1, only 48% of the total water use is estimated to be from groundwater (Table 9-2). It is likely that most of the surface water use occurred for agriculture south of Highway 20, while most groundwater use occurred north of Highway 20 for agricultural, municipal, and industrial uses.

Table 9-1 Estimated water use in the Middle Creek Watershed for the year 2000.

Water User	Total Water Use (acre-feet)[a]	Adjusted Total Water Use (acre feet)[b]
Municipal & Industrial	274	274
Agricultural	6,637	7,391
Conveyance Losses	204	204
Total	7,261	7,869

[a] *Lake County Water Inventory and Analysis Final (CDM and DWR 2006c).*
[b] *Adjustments to more accurately reflect water use include the following: Because water use for frost protection was not included, water use for pears and grapes was increased by 39% based on Christensen Associates, Inc. 2003.*

Table 9-2 Sources for water use in the Middle Creek Watershed in 2000.

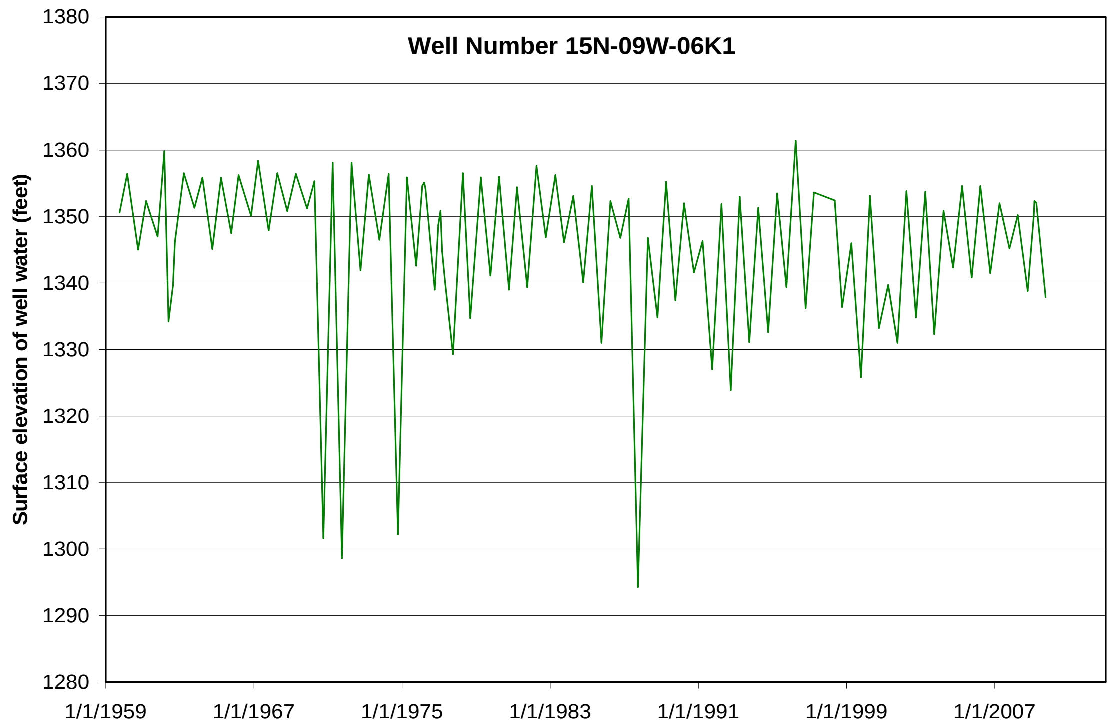
Water Source	Total Use (acre-feet)	% of Total
Surface Water	3,735	52
Groundwater	3,380	48
Total	7,115	

Recent trends in agricultural crops have probably changed water use since the LCWIA was completed. While Lake County pear acreage has declined continuously since its peak in 1980, it has continued to decline sharply in recent years. For example, acreage decreased 47% from 2000 to 2007 (LCDA various). The Middle Creek area has seen a decline similar to the county trend. In some cases pears have been replaced by irrigated walnuts, pasture, or vegetable crops, however in many cases, land is fallow or un-irrigated pasture. From 2000-2007, wine grape acreage increased from approximately 6,800 to 8,300 acres; however, the acreage has remained constant since about 2006 due to a downturn in the wine grape market. Some pear acreage in the Middle Creek Watershed may have been replaced by wine grapes during the years 2000-2007; however, on an area basis, wine grape irrigation use is about ¼ that of pears.

At a March 13, 2008 meeting on historical watershed conditions, long time Middle Creek Watershed residents discussed changes they had observed in well levels. Matt Hutton, a second generation local well driller, noted that wells located in the main alluvial fan near Upper Lake no longer run artesian. As an example, he said that a well near the ranger station ran artesian when it was first drilled, and now has a water level down at 50 feet. Alex Suchan observed that well levels had dropped as more and more pear orchards were planted, and that the water table may be up as a result of the decline in pear acreage.

Wells monitored by the Lake County Department of Public Works show higher fall water wells beginning in 2004 than in previous years (Figure 9-1).

In addition the difference between spring and fall groundwater levels, which indicates the amount of pumping, decreased beginning in 2004.



Source: Lake County Department of Public Works

Figure 9-1 Well water levels measured in well number 15N-09W-06K1, located approximately 0.1 miles north and 350 feet east of the intersection of Pitney Lane and Elk Mountain Rd.

Along with the water inventory and analysis, a water demand forecast was developed for Lake County (CDM and DWR 2006a). Because the population is forecast to increase 62% by 2040, residential water use was forecast to increase by the same amount. In order to give a range of possible long term agricultural water requirements, three scenarios for future agricultural water demands were developed (Table 9-3). All three include removal of substantial areas of pears and walnuts and a large increase in the area of vineyards. Because vineyards require less irrigation water than do pear orchards, Scenarios 1 and 2 show a decline in water use. Scenario 3 assumes replacement of pear and walnut acreage with crops with a similar water demand. Complete details for the three scenarios are given in Appendix E. Again, frost protection water is not included in the projected water demand estimates.

Table 9-3 Current (2000) and projected (2040) water demand for the Middle Creek Watershed under three different cropping scenarios.

	Irrigated Cropland (acres)	Average Year Applied Water (acre-feet)
Current (2000)	2,142	6,637
2040		
Scenario 1	1,722	5,223
Scenario 2	1,843	5,526
Scenario 3	2,342	6,791

10.0 Terrestrial Wildlife Habitats and Species

10.1 Natural Habitats

Just south of the Middle Creek Watershed, between the watershed and Clear Lake, lies an area of wetlands and agriculture reclaimed from wetlands. Moving up to the lowest portion of the Middle Creek Watershed, the broad level valleys may once have supported grasslands, oak woodlands, and riparian vegetation. Today these areas have been converted almost completely to agriculture. Hills surrounding these valleys support a combination of chaparral, and oak or mixed oak and conifer woodlands (Plate 12). Throughout the watershed, chaparral is common on south facing slopes, while Douglas fir and mixed conifer/hardwood forests are common on north facing slopes. A more detailed description of these habitat types follows.

Wetlands South of the Middle Creek Watershed, Rodman Slough is a wetland area that extends to Clear Lake. Adjacent to Rodman Slough are agricultural lands, farmed primarily for wild rice, that were reclaimed from wetlands. Wetlands are very productive wildlife habitats providing food, cover, and water for more than 160 bird species, and many mammals, reptiles, and amphibians (DFG 1988). They are characterized by rooted, erect aquatic plants such as common cattail and tule bulrush. The state Department of Fish and Game (DFG) and USACE have proposed wetland restoration and wildlife areas in the Reclamation Area that would restore large areas of wetlands and provide valuable wildlife and fish habitat (Section 16.6).

Riparian Habitats are relatively narrow strips of land bordering streams, rivers, and other water bodies. The vegetation in riparian areas differs from the surrounding landscape because it requires or tolerates wet and sometimes flooded conditions. Although riparian habitat makes up a small proportion of the total land area, it is important habitat for a wide variety of animals. Of all California animal species, an estimated 25% of land mammals, 40% of reptiles, and 83% of amphibians depend on riparian habitats for some or all of their life cycle (Brode, J.M. and R.B. Bury 1984, Williams, D.F. and K.S. Kilburn 1984). Riparian habitats are considered the most critical habitat for conservation of resident and Neotropical migrant birds in the western U.S. Riparian vegetation provides shade, food, and nutrients that are the basis of the aquatic food chain. Despite the importance of riparian habitat, it is estimated that only 2-15% of historic riparian habitat remains in California (CalPIF 2004).

Riparian habitats follow Middle Creek and its tributaries throughout the watershed; however, they are not shown on the landcover map because their extent is smaller than the area of the vegetation map units, which are 100m X 100m. In the lower portions of the Middle Creek Watershed, overstory vegetation frequently includes willow, cottonwood, and oak. In valley areas with deep soils and good water availability, riparian habitats in their natural state have complex, multi-layered tree and shrub canopies that are important to a wide array of wildlife and fish. The natural meandering of streams in nearly level valleys promotes a mosaic of riparian vegetation stages. Riparian vegetation described along the upper portion of the east fork of Middle Creek includes alder, oak, maple, and fir (USFS 1980). Along the ephemeral streams in the highest areas of the watershed, riparian vegetation frequently consists of a single layer typical of the surrounding vegetation.

Oak woodlands The level agricultural valleys in the lower portions of the Middle Creek Watershed have been most heavily modified from their natural condition. Agricultural fields and orchards in these areas were probably once dominated by valley oak woodlands. These oaks provide nesting sites for cavity nesting birds and acorns that are an important seasonal food source for many animals and birds. Today valley oaks are often found along watercourses and roads throughout the lower watershed.

Blue oak woodlands are the predominant hardwoods on south and west facing slopes at lower elevations, and they thrive in hot, foothill areas with shallow soils. In the Middle Creek Watershed, the largest area of blue oak is found mixed with foothill pines in the hills north of Clover Valley (mapped as hardwood in Plate 12). The under-story in blue oak, grey pine habitat contains an array of introduced grasses and forbs which have replaced native perennial bunch grasses, and it may contain shrubs such as ceanothus and manzanita (CalPIF 2000, DFG 1988). Like valley oaks, the acorns from blue oaks provide a vital seasonal resource to wildlife including birds, small mammals, and deer.

Statewide, both valley and blue oaks have been identified as showing locally poor to moderate regeneration resulting in concern for their future viability as a forest type. Young, first year seedlings and old trees are present, but a combination of competition from introduced grasses, fire suppression, and herbivory appears to reduce seedling survival (CalPIF 2002b).

Montane hardwoods are found on north facing slopes throughout the watershed. Dominant trees include interior live oak, canyon live oak, California bay laurel, madrone, black oak, and Douglas fir. Significant areas of montane hardwood habitat are found along the west fork of Middle Creek. As always, acorns provide a vital food source to birds and wildlife. Many amphibians and reptiles are found on the forest floor of these north-facing, cooler hardwood forests (DFG 1988).

The types of oaks found in montane hardwood habitat have not been found to have problems with regeneration, but some of them are susceptible to sudden oak death (SOD), caused by the agent, *Phytophthora ramorum*. This pathogen infects a wide range of plant species (including bay laurel, manzanita, Douglas fir, rhododendrons, and buckeye), but causes mortality in only a few (including tanoak, California black oak and coast live oak). SOD has not been found in the Middle Creek Watershed, and the risk of SOD spread may be low because the watershed is inland from the coastal fog belt where SOD is prevalent. Nevertheless, watershed residents and visitors should avoid introducing potentially contaminated plant material or soil attached to vehicle tires and shoes from infected areas (COMTF 2004). Lake and other counties where SOD has been found are under state and federal quarantines regulating transportation of wood products and nursery plants that host SOD[15].

Figure 10-1 Mixed hardwood, conifer forest on west side of main branch of Middle Creek, Clear Lake in background. *Photo by Greg Dills taken April 13, 2009.*

[15] SOD has been found only in the southern end of Lake County near the border with Sonoma County.

Grasslands are found scattered throughout the Middle Creek Watershed, frequently on south-facing slopes. Beginning with the first Spanish colonists in California, livestock grazing led to replacement of native perennial bunch grasses with non-native annual grasses in about 100 years. Most of California's original grasslands have been converted to agriculture, and today the majority of California grasslands occur in areas that were cleared by ranchers from shrub and oak woodlands (CalPIF 2000, DFG 1988). In most of California grasslands (and in other habitats with a grass understory), common annual grasses include wild oats, soft chess, ripgut brome, red brome, wild barley, and foxtail fescue. Common forbs include filarees, turkey mullein, clovers, and popcorn flower.

Chaparral is brushy habitat that occurs on dry, shallow soils of hill- and mountainsides. Chaparral plants are adapted to fire; some have seeds that germinate following fire and roots that re-sprout following fire. Many chaparral plants have evergreen leaves covered with a heavy waxy cuticle to prevent water loss. Dominant plants in chaparral include scrub oak, chaparral oak, chamise, and several species of manzanita and ceanothus (DFG 1988). On north- and east-facing slopes, plant species change due to reduced sunlight and water stress. Dominant species include scrubby live oak and canyon oak, mahogany, ceanothus, madrone, bay and sometimes black oak (DFG 1988, Nielson and McQuaid 1981). At the highest elevations of the Middle Creek Watershed, chaparral is most often found on south facing slopes with shallow and/or well-drained soil conditions. Common plants include manzanita and ceanothus, and scattered ponderosa pine and Douglas fir may be present (Lauren Johnson, personal communication).

Chaparral plant communities change following wildfire. For 1-3 years after a fire, herbaceous cover dominates, while re-sprouted shrubs increase in size. Brush canopy begins to dominate from 3 to 15 years following the fire. From 10 to 30 or more years after a fire, the canopy closes together and dead plant material accumulates (DFG 1988). Prescribed burning provides a mosaic of stages in chaparral growth with greater food availability and structurally diverse habitats.

Conifers The dominant conifer forest type in the Middle Creek Watershed is Douglas fir. Other trees found in Douglas fir habitat are pacific madrone, black oak, canyon live oak, sugar pine and ponderosa pine. Plantations planted in the Middle Creek Watershed following the Round Burn in 1966 are exclusively ponderosa pine. Following the Fork Fire in 1996, most of the trees that were planted were ponderosa pine, but some plantations included Douglas fir and sugar pine (James Donahey, personal communication).

Figure 10-2 Plantation with significant brush growth. Planted after 1996 Fork Fire. *Photo by Greg Dills taken April 13, 2009.*

Figure 10-3 Trees re-planted after 1996 Fork Fire. This area is at higher elevation than the previous figure. *Photo by Greg Dills taken April 13,2009.*

Closed-cone Pine-cypress Knobcone pine is found within surrounding areas of chaparral and forest. These conifers rely on fire for their seeds to germinate, and the full sunlight present following a wildfire promotes seedling establishment and dense, even-aged stands of these trees.

A list of plants found on MNF lands in the Middle Creek Watershed is given in Appendix F.

10.2 Wildlife

A MNF list of mammals, reptiles and birds found in the Middle Creek Watershed is given in Appendix F. The 1999 Watershed Analysis Report includes a chapter on fish and wildlife that discusses current conditions and trends. This section briefly summarizes the findings of the chapter and includes some additional material.

The success of different wildlife species depends on the presence of suitable habitats, and a significant control on habitat conditions are the frequency and intensity of wildfire in the watershed. Black-tailed deer thrive in areas with early to mid-successional forest, woodland, and brush habitat[16]. Therefore, the Fork Fire in 1996 probably led to an increase in suitable deer habitat and increase in the deer population. As the brush fields mature, they become less suitable as deer browse because they become impenetrable and the tender leaves become too high for deer to reach. A program of prescribed burning of chaparral leads to a patchwork of successional stages and has the potential to support more stable deer populations (USFS 1999). Animals that rely on old growth or late successional habitat, such as the northern spotted owl, marten, and pacific fisher, can also be threatened by a build up of fuels in forested areas and surrounding chaparral. Decades of fire suppression have led to high fuel loads and more intense wildfires. A significant portion of potential northern spotted habitat in the watershed was burned by the Fork Fire (USFS 1999).

A description of species of concern[17] found on MNF lands in the Middle Creek Watershed and their habitat requirements is found in Appendix 1, Section A1.6 of the 1999 Watershed Analysis Report. An updated list of these species is given in Table 10-1 below.

[16] Succession is the process by which plant and animal communities that dominate after disturbance are gradually replaced by other plant and animal communities.
[17] Species of concern refers to species that are declining in population or are considered to be in need of conservation.

Table 10-1 Animal species of concern possibly found in the Middle Creek Watershed.

Habitat and associated animals*	Status**
Aquatic habitat	
Rainbow trout (resident)	M
Riparian habitat	
California red-legged frog	T
Northern red-legged frog	S, SC
Foothill yellow-legged frog	SC
Tailed frog	SC
Southern torrent salamander	
Western pond turtle	S,SC
Willow flycatcher	S
Late successional forest habitat	
Bald eagle	S,M
Northern spotted owl	T,M
Pacific Fisher	S,M,SC
Marten	S,M
Northern goshawk	S,M,SC
Multi-habitat	
American peregrine falcon	M
Pallid bat	S
Townsend’s big-eared bat	S
Western red bat	S
Black-tailed deer	M

**Chinook salmon and Steelhead Rainbow trout removed, as these fish not present in the Middle Creek Watershed. List of bat species changed based on information from April Hargis, Biologist MNF.*

*** T=federally threatened, S=Forest Service sensitive, M=Forest management indicator species, SC=listing may be appropriate, but the U.S. Fish and Wildlife Service lacks sufficient information to support a listing proposal.*

The California Natural Diversity Database (CNDDB) collects information on the location and status of rare and endangered plants, animals, and natural communities as they have been discovered and reported to the CNDDB. Table 10-2 summarizes CNDDB listings for the Middle Creek Watershed.

Table 10-2 Species of concern in the Middle Creek Watershed as reported in the 2006 version of the CNDDB.

Common Name	Scientific Name
ANIMALS	
MAMMALS	
American badger	*Taxidea taxus*
Humboldt marten	*Martes americana humboldtensis*
Pacific fisher	*Martes pennanti (pacifica)* DPS
BIRDS	
purple martin	*Progne subis*
REPTILES	
northwestern pond turtle	*Emys (=Clemmys) marmorata marmorata*
AMPHIBIANS	
foothill yellow-legged frog	*Rana boylii*
FISH	
Clear Lake hitch	*Lavinia exilicauda chi*
PLANTS	
Anthony Peak lupine	*Lupinus antoninus*
glandular western flax	*Hesperolinon adenophyllum*
Konocti manzanita	*Arctostaphylos manzanita ssp. elegans*
Norris's beard-moss	*Didymodon norrisii*
Rincon Ridge ceanothus	*Ceanothus confusus*
small-flowered calycadenia	*Calycadenia micrantha*
Sonoma manzanita	*Arctostaphylos canescens ssp. sonomensis*

11.0 Aquatic Wildlife Habitats and Species

11.1 Upper Watershed

Rainbow trout were found to be abundant in upper portions of the east fork of Middle Creek in 1980 (USFS 1980). Foothill yellow-legged frogs are considered to be abundant in the watershed, and there is potential California red-legged frog habitat in the watershed, although their presence has not been confirmed (USFS 1999). Foothill yellow-legged frogs are a California species of special concern, and California red-legged frogs are a California threatened species in this area (DFG 1994). Factors contributing to the decline in populations of these frogs include the introduction of exotic species such as bullfrogs, changes in water flow due to water diversions, and siltation due to land use activities that increase erosion. Western pond turtles, found primarily in the main stem of Middle Creek, have the potential to exist throughout the Middle Creek Watershed; however, the presence of bullfrogs threatens their expansion (USFS 1999).

Much of the watershed of the east fork of Middle Creek burned during the 1996 Fork Fire. In some areas, the fire burned riparian trees, leading to reduced cover and higher water temperatures (Figure 11-1). Sediment loads to the creek increased, especially the first year after the fire. The USFS estimated that the changes in stream temperatures and siltation would affect aquatic species for at least a decade (USFS 1999).

Figure 11-1 Upper portion of east fork of Middle Creek, April 13, 2009, almost thirteen years after the Fork Fire. The clearing is Middle Creek Flat. Photo is taken looking northwest, and the creek flows from the lower right corner of the photo toward the upper middle portion of the photo.

11.2 Lower Watershed

There were five native fish species that used Clear Lake tributaries such as Middle Creek for spawning. Three of these, the Clear Lake hitch, *Lavinia exilicauda chi*, the Clear Lake splittail, *Pogonichthys ciscoides*, and the Sacramento pikeminnow, *Ptychocheilus grandis*, were large minnow species that contributed to "enormous spring migrations up tributary streams" (Cook, S.F. et al. 1966). The hitch still spawn in Middle Creek and other tributaries of Clear Lake, and their biology and current status is discussed in detail below. The Clear Lake splittail was found only in Clear Lake and its tributaries. Its population underwent drastic reductions in the early 1940s, and it has not been observed since the 1970s. Earlier drying of Clear Lake tributaries due to diversion of water and groundwater pumping may have contributed to the demise of the splittail. Peak splittail spawning occurred two weeks after that of the hitch, and it had a longer requirement for its young to remain in nursery streams than do hitch (Cook, S.F. et al. 1966, Macedo, R. 1994).

The Sacramento pikeminnow was previously called the Sacramento squawfish. Like the Clear Lake splittail, populations of the Sacramento pikeminnow in Clear Lake declined drastically in the early 1940s. The pikeminnow is a fluviatile or river-adapted species, unlike the Clear Lake hitch and splittail which have become adapted to lake conditions.

The Sacramento sucker, *Catostomus occidentalis*, is a native fish with a similar history to the pikeminnow. Although it was not recorded as part of large spring migrations, it was frequently taken by hook and line from Clear Lake prior to the 1930s, and became rare by 1966. Like the pikeminnow, suckers are stream and river adapted.

Tributaries of Clear Lake were spawning streams for steelhead (anadramous Rainbow trout) prior to the 1914 construction of a dam across Clear Lake's outlet on Cache Creek. The Pacific Lamprey, *Lampetra tridentatea*, is also listed as having occurred in Clear Lake, but now extinct there.

Many of the introduced warm water fish species found in Clear Lake can be found in lower portions of Clear Lake tributaries. Fish that have been observed include bullhead, catfish, carp, and largemouth bass (Richard Macedo, personal communication).

Figure 11-2 Salamander observed in Middle Creek during the 2005 creek walks. *Photo courtesy of Sunny Franson.*

11.2.1 Clear Lake Hitch

Recovery of the Clear Lake hitch, a subspecies found only in Clear Lake and its tributaries, has become the focus of a local CRMP group called the Chi Council. The hitch is a large minnow that has been designated a species of special concern in California because of decreasing populations and limited geographic distribution (Moyle et al. 1995). Their spawning runs were once one of the most impressive natural events in the tributary watersheds of Clear Lake:

> Hitch mass by the thousands and ascend the many streams leading into Clear Lake. The tumultuous splashing in creeks and the appearance of herons, osprey, egrets, and bald eagles in trees overhanging streams signify to the human observer that the hitch are in. Along stream banks, raccoons, mink, otter, and even bears join the birds to feast on hitch as they make their way up swiftly flowing streams (Macedo, R. 1994).

The hitch was also once a staple food for native peoples. They were dried and eaten year round and were used as a trade item.

There is limited documentation of historic hitch populations. Pre-1900s historical records described streams that were packed solid with fish on some years (Allison G.M. and W. R. McIntire 1949, Rideout, W.L. 1899), and a 1960s study of fish in Clear Lake considered the hitch to be abundant (Cook, S.F. et al. 1966). Local residents agree, however, that runs in recent years are much reduced relative to earlier decades, and hitch have disappeared from Schindler and Seigler Canyon Creeks where they once occurred.

Since 2004 a local group, the Chi Council, has been carrying out volunteer monitoring of hitch spawning runs. This group has documented annual variability in hitch runs and a possible a decline in the populations spawning in Clover and Middle Creeks. In 2005 in Middle Creek, schools of hitch with from 150 to over 400 individuals were observed at Highway 20, and 40-50 were observed at the Rancheria Bridge. In 2005 in Clover Creek, schools with up to 100 individuals were observed. In 2006 and 2007, no hitches were observed in Middle or Clover Creeks. In 2008 hitch were observed in Clover and Middle Creeks, but the largest school observed was 35 individuals. In 2009 the largest school of hitch observed in Middle Creek was 20 individuals. None were observed in Clover Creek in 2009 (Chi Council 2009).

Numerous factors are believed to contribute to the decline in hitch populations. Many fish species introduced to Clear Lake over the past century feed on hitch juveniles, and channel catfish and large-mouth bass feed on adults (Moyle P.B. et al. 1995). Other introduced species such as the Mississippi Silversides and threadfin shad compete with hitch for food. Wetlands along the shores of Clear Lake are important habitat for juvenile hitch and have declined by 79% from their original extent (Week 1982)[18]. Spawning habitat has been reduced because streams dry up earlier than in the past, and because of barriers to migration.

The major barriers to hitch migration on Middle Creek were described in Section 6.2. Additional smaller barriers are likely to be present, and a survey to identify and prioritize all barriers to hitch migration is an important first step to eliminating these barriers. There are many unknown factors about the hitch, for example their swimming capabilities and requirements for fish passage, the importance of shoreline habitat in juvenile hitch survival, and factors determining the size and success of spawning runs. In 2009, several local Tribes joined together in a program for tagging and releasing hitch to better understand their migration. The Chi Council continues to pursue contacts and funding with government agencies and academic institutions to study the hitch and improve their habitat (Chi Council 2004). Local Tribes began a hitch tagging study in 2009, and they are developing an Adaptive Management Plan that will address migration barriers, high nutrient loads, water use for agriculture and development, and stream flows.

A more detailed description of the hitch life cycle and the reasons for the decline in hitch populations is given in Appendix G. A list of the fish found in Clear Lake is given in Appendix H.

12.0 Invasive Species

Invasive species are a form of "biological pollution", capable of damaging ecosystems just like other forms of pollution. Invasive species are defined as any non-native species "whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health" (United States 1999). They include plants, animals, and disease-causing microorganisms such as bacteria and fungi, and they occur in all ecosystems from lakes and streams to forests, grasslands, and agricultural areas. Some traits that are common to invasive species include rapid growth and reproduction, and the abilities to spread, adapt to a wide range of conditions, and live off a range of food types (Wikipedia 2008). Once established, invasive species may be spread both by human activities and natural causes such as animal movement, wind, or water movement. However, in most cases the original introduction of a non-native species occurs due to human activities.

Identification of which species are invasive is complicated by differing human perspectives. While a non-native species may provide benefits to some

[18] Week estimated an 84% reduction in the original area of wetlands, however this included temporary conversion of Anderson Marsh to agriculture. It has since reverted to wetlands and been acquired as part of a state park.

people, if its negative effects outweigh the beneficial effects, it is considered invasive. An example is water hyacinth which has been popular in aquatic gardens, but when it escaped to natural areas, it completely covered lakes and rivers, devastating their ecology. As a practical matter "because invasive species management is difficult and often very expensive, these worst offenders are the most obvious and best targets for policy attention and management" (NISC 2006). Invasive species are also considered to be those not under human control or domestication. Therefore, escaped domestic plants and animals can be considered invasive if they meet the definition of invasive species (NISC 2006).

12.1 Terrestrial Invasive Species

12.1.1 Plants

Invasive species are a continuing problem leading to:

- Reduction of native plant populations, including endangered species.
- Loss of wildlife habitat and food sources.
- Degraded range and timber lands.
- Increased fuel loads.
- Reduced water resources.

A brief summary of the plants considered to be most noxious in Lake County is given in Table 12-1. A more detailed description of these invasive plants is found in a pamphlet called 'Invasive Weeds of Lake County', and internet resources on invasive species are listed in Appendix A .

Mapping for arundo and tamarisk has been carried out under a grant received by the West Lake RCD and LCPWD. Starting in 2001, the Lake County Weed Management Area (LCWMA), began a program to monitor and eradicate arundo and inventory tamarisk throughout the county. The program has located 22 arundo sites and one tamarisk site in the Middle Creek Watershed (Plate 13). Funding to eradicate arundo is on-going.

Two small Scotch broom occurrences were identified and manually controlled by MNF personnel at the Deer Valley Campground in 2008. These sites will be monitored and re-treated as necessary. Scotch broom is also found along Elk Mountain Road above the Middle Creek Campground (Lauren Johnson, personal communication).

Table 12-1 Invasive terrestrial weeds in Lake County.

Name	Description	Economic or Environmental Harm
Arundo/Giant Reed *Arundo donax*	10-20 ft. tall cane-like stems, perennial.	Found in riparian areas; Excludes other vegetation creating monoculture unsuitable for bird and wildlife habitat.
Brooms, Scotch & French *Cytisus scoparius & C. monspessulanus*	5-10 ft. tall shrubs with yellow flowers in late spring.	Replaces native woody and annual species; Prevents tree seedling growth; Increases fuel load.
Medusa Head *Elymus caput-medusae*	Winter annual grass resembling foxtail, 10-12 in. tall.	Replaces desirable rangeland forage plants; High silica content makes it unpalatable to livestock and wildlife.
Milk thistle *Silybum marianum*	6 ft. tall thistle with 2 ft. long dark green leaves, pink flowers in late spring.	Forms dense, impenetrable thickets; Can be poisonous to livestock.
Perennial Pepperweed/White top *Lepidum latifolim*	2-4 ft. tall stalks, white flowers in early June.	Common in riparian areas, roadsides and fields; Displaces native species and habitat.
Puncture Vine/Goats Head *Tribulus terrestris*	Annual, forms circular, flat mat, seeds sharp, yellow flowers.	Found in disturbed areas; Seeds that form by late summer puncture bicycle tires, injure feet and hooves.
Tamarisk/ Salt cedar *Tamarisk sp.*	Large, up to 25 ft. tall shrub, pink blooms in late spring.	Grows in stream channels, moist areas; Eliminates native plants through rapid growth and reproduction and accumulation of salt in soil; High water user (up to 300 gallons per day).
Tree of heaven/Chinese Sumac *Ailanthus altissima*	Deciduous tree with large, compound leaves, yellow green flowers become papery seeds.	Extensive, vigorous root system damages roads, sidewalks, buildings; Spreads; Toxin from roots inhibits other plants.
Yellow Starthistle *Centaurea soltitalis*	Annual or biennial weed, up to 3 ft. tall, yellow flowered, spiny seed heads.	Poisonous to horses, mules, and donkeys; Poor forage for cattle; Competitive, replaces desirable plants.

Source: Lake County Agricultural Commissioner. 2002. Invasive Weeds of Lake County.

12.1.2 Animals

Often the populations of threatened and endangered animal species are reduced by habitat loss and degradation. The addition of a non-native species as a predator or competitor can pose a serious additional threat.

Examples of mammals that may be considered invasive include the roof rat, Norway rat, and feral cats, all of which prey on ground nesting birds. Feral pigs cause environmental damage digging up the soil and causing erosion and feeding on native wildlife and vegetation. At the same time, feral pigs provide popular hunting activites. DFG reported 5,438 were taken in the state in 2005/2006 (Kreith, M. 2007).

The European starling was introduced to the United States in 1890 and is a widespread species that competes with other birds for nest cavities. Brown-headed cowbirds were once found only in the Midwest where they followed bison herds. They have shifted to reliance on livestock and agricultural areas, and their range has expanded to most of North America. Cowbirds are brood parasites, laying their eggs in the nests of other birds, and they can seriously affect reproduction of numerous songbird species.

With a $31 billion agriculture industry in California, introduced insect pests pose a significant economic threat. In addition, eradication or control of the pests may require increased pesticide use with the potential for environmental harm. Insect pests newly introduced to California with the potential to damage Lake County crops include two vineyard pests, the glassy-winged sharpshooter and vine mealybug, and the light brown apple moth, which threatens a variety of orchard crops and grapes. Other insect pests that may affect agriculture, landscape, and forest plant species include several fruit fly species, the Japanese beetle, and the Gypsy moth. The Lake County Agriculture Department (LCAD) has trapping programs for these pests (Section 16.9). Thus far the county appears is free of them with the exception of vine mealybug, which has been found in one vineyard outside the Clear Lake watershed.

12.1.3 Diseases and Parasites

Some diseases and parasites are included in definitions of invasive species (NISC 2006). Although no guidelines were found on what was included, it appears that only recently introduced diseases and parasites with a source or vector in the natural environment are considered. West Nile virus, transmitted by mosquitoes and causing disease in humans and birds, is considered an invasive species. The Lake County Vector Control District monitors for the presence of West Nile virus and controls mosquito populations in the county. Sudden Oak Death is a disease affecting many oaks in coastal areas. (Section 10.1)

12.2 Aquatic Invasive Species

12.2.1 Plants

Many invasive aquatic plants arrived as aquarium (hydrilla and Eurasian water milfoil) or landscaping plants (water hyacinth, water primrose) (Table 12-2).

[20] One CCF is one hundred cubic feet.

These plants have the ability to form dense mats, interfering with boating and swimming. When they reach the surface or float on the surface, they provide habitat for mosquito larvae in small protected pools of water in their foliage.

Table 12-2 Invasive aquatic plants in Lake County, California.

Name	**Description**	**Economic or Environmental Harm**
Hydrilla *Hydrilla verticillata*	Rooted, submerged plant with branching stems, pointed leaves, reaches up to 36 ft.	Forms dense vegetation mats that interfere with recreation and destroy fish and wildlife habitat; Spreads by fragmentation, seeds, tubers.
Eurasion Watermilfoil *Myriophyllum spicatum*	Rooted, submerged plant with feathery leaves., 3-10 ft. tall or more.	Forms very dense mats; Spreads by fragments; Competetive due to early spring growth.
Water hyacinth *Eichornia crassipes*	Free-floating with rounded, leathery leaves, large purple to violet flowers, few inches to 3 ft. tall.	Rapid growth and reproduction cause rapid extension of free-floating mats; Seeds eaten and transported by water fowl.
Water primrose *Ludwigia peploides & L. hexapetala*	Bright yellow flowers and willow-like leaves, creeping on shoreline, floating, or upright.	Forms dense mats of vegetation, primarily along margins of lakes and streams; Spread by seeds and plant fragments; Out-competes tules and other emergent aquatic vegetation.

Source: Lake County Agricultural Commissioner. 2002. Invasive Weeds of Lake County.

Of the plants listed in Table 12-2 hydrilla is considered the most serious invasive plant because of its ability to spread rapidly and form dense mats throughout the water column. It is an A rated pest by CDFA, requiring eradication. In 1994, it was discovered in Clear Lake, and an eradication program was begun the same year. Following three seasons without hydrilla detection in Clear Lake, no herbicides were applied to control hydrilla in 2006 (CDFA 2006). In 2007 and 2008, however, additional hydrilla finds were made and control resumed in the areas of the finds. The CDFA Hydrilla Program crews monitor for other invasive and native aquatic submerged plants as part of the program to monitor for hydrilla.

Water primrose is a damaging invasive because of its competition with tules, which provide important nesting habitat for western grebes. Eurasian water milfoil is present in Clear Lake, but has not reached damaging populations. A population of water hyacinth was detected in Clear Lake and was removed.

12.2.2 Animals

Bull frogs, *Rana catesbeiana*, are native to the eastern United States, and were introduced to California around 1900. Along with invertebrate prey, adult bull frogs prey on other amphibians and even mice, snakes, turtles, and birds. They damage native amphibian populations both by preying on them and by competing for space, and they prey on young western pond turtles (DFG 2005).

Numerous fish species have been introduced to Clear Lake (Appendix H), and these introductions have reduced native fish populations. Some of the introduced fish such as bass, bluegill, crappie, and catfish, prey on juvenile fish, and bass and catfish consume adult fish as well. Other introduced fish, such as the silversides and shad, are planktivores that compete for food with native fish like the Clear Lake hitch, which rely on the same food source. The introduced fish species are not considered invasive because many provide the benefit of improved sport fishing and because elimination of the introduced species is not possible. Management, for example increasing wetlands important for the survival of juvenile fish, may help to insure the success of native fish populations.

Non-native freshwater mussels, such as the quagga and zebra mussels and New Zealand mud snail, pose a significant threat to Clear Lake. Both of the mussel species reproduce rapidly, covering hard surfaces, clogging water intake pipes, and covering beaches with their small, sharp shells. They are filter feeders capable of consuming a large proportion of the plankton, microscopic floating plants and animals, present in a water body. Because plankton are the base of the food chain for aquatic ecosystems, this can severely affect the entire ecosystem. Both species are found throughout the eastern United States, and both are now found in several water bodies in California (USGS 2008). To prevent their introduction into Clear Lake water bodies, the Lake County Board of Supervisors adopted an urgency ordinance on March 25, 2008 requiring inspection of all vessels entering Clear Lake (Lake County 2008).

The New Zealand mud snail is found in scattered locations around California. It prefers moving water and is found in streams, rivers, and lakes. It may have the potential to out-compete native invertebrates that are important food sources for fish such as mayflies, caddisflies, and chironomids. It is readily spread by wet fishing gear, and drying out or freezing wet gear is recommended when moving from one water body to another (DFG 2008).

13.0 Fire and Fuel Load Management

With California's dry summers, fire is a natural occurrence, and many plants and animals are adapted to fire. The severity of wildfires depends on the dryness of vegetation and ground cover, weather conditions such as wind speed and temperature, and the amount of fuel available. The severity and extent of fires determines the damage to wildlife and plant communities, as well as the potential erosion, sedimentation, and changes in hydrology following a fire. Wildfire damage to people, their communities, and livelihoods depends on where people choose to live and work and how they manage surrounding fire-prone areas. Prescribed or controlled burning helps to avoid the build up of heavy fuel loads, and therefore, the potential for severe wildfires.

13.1 Fire Cycles

> "Where there is fire, there is a fire cycle. The fire cycle is the number of years, on average, that a fire historically moved through the area. It is also called the fire return interval. Every ecosystem has a fire cycle. Even the coastal areas have fire cycles, though they are very long—perhaps 300 years or more. But in very hot, dry areas, fire cycles might be as short as every 1–7 years" (Nunamaker, C. 2002).

The quote above refers to natural fire cycles in California, which are determined by factors such as vegetation, dry weather conditions, and the frequency of thunderstorms. For the California North Coast a ranking of the length of natural fire cycles, which includes fire ignition by Native Americans, states "In general the most frequent fire occurred in grasslands and oak woodlands, with decreasing fire frequencies in chaparral, mixed evergreen, and montane mixed conifer" (Stuart, J.D. and S.L. Stephens 2006).

An excellent discussion of the use of fire by Native Americans is given in the 1999 Watershed Analysis Report, and a brief excerpt is included here: "Several objectives of burning by the California Indians can be inferred based on the literature. These include fire management, maintenance of habitat diversity for prey, favoring vegetation for food sources, and producing quality vegetative material for baskets and other implements" (USFS 1999).

While early settlers in the Middle Creek area used fire extensively to promote grazing opportunities, (Section 3) a policy of fire exclusion was adopted by the USFS in the early 1900s. Over decades, this led to a build up of fuels and "those few fires which do escape early containment, especially those on south and west aspects, tend to become larger and more destructive than in the past" (USFS 1999). Since the 1920s, nearly all of the upper Middle Creek Watershed has burned one or more times (Plate 11). In recent decades, foresters and ecologists have recognized that fire is a natural ecological process, and "the best management strategy is thought to be a return to a regime of more frequent, less intense fires" (USFS 1999).

An analysis of fires in the Middle Creek Watershed from 1909-1996 is found in Appendix 3 of the 1999 Watershed Analysis Report. This analysis found that there was a greater percentage of human-caused fires, and greater average fire size in the Middle Creek Watershed as compared to the entire MNF. The analysis noted that there are large areas of fire-prone vegetation, such as chamise and knobcone, fuel build-up due to fire suppression, and a drier climate in the Middle Creek Watershed compared to MNF as a whole.

13.2 Fire and Natural Communities

There are many examples of plants in the Middle Creek Watershed that are fire-adapted. The importance of fire in chaparral is recognized in most definitions of the plant community. "Chaparral is a shrubland or heathland plant community found primarily in California, USA, that is shaped by a Mediterranean climate (mild, wet winters and hot dry summers) and wildfire" (Wikipedia 2007). Many chaparral plants have seeds that require intense heat to germinate and/or fire-resistant roots that enable them to re-sprout quickly following a fire (CDFFP 2001). Oak trees can withstand burning of much of their foliage. Even when severe fires kill the tops of oak trees, many will sprout from their base the following year (McCreary, D.D. 2004). Ponderosa pine is adapted to high frequency, low intensity fires that create open stands with little understory. At 5-6 years of age, ponderosa pines shed lower limbs and develop thick bark and deep roots that enable them to withstand low intensity fires. Douglas fir is also considered better able to withstand fire than most conifers (NIFC, 2008).

13.3 Fire effects on Erosion and Hydrology

Undisturbed soils in natural ecosystems are usually well covered with a combination of vegetation such as grasses and herbaceous plants, duff (plant residues), and woody debris. With greater fire severity, more of the soil cover is removed, which exposes the mineral layer to raindrop impact and overland flow. When vegetation is removed, dry ravel and debris movement is more likely, especially on steep slopes. Fire can also increase water repellency of soil, which increases surface water run-off. Creation of water repellency is unlikely under prescribed fire conditions when initial soil conditions are usually wetter (Robichaud, P.R. 2000).

At a larger scale, the amount of erosion that occurs and the delivery of sediment to water courses depends on numerous factors:

- The steepness of the area that is burned.
- The severity, extent and spatial variability of the fire.
- The presence of highly disturbed areas such as skid trails for logging.
- The severity of post-fire rainfall.

Even the fire suppression response, for example using bulldozers to create fire lines, contributes to erosion. Although such areas are frequently rehabilitated prior to rainfall, they are still likely to have higher than pre-fire levels of erosion (Robichaud, P.R. 2000, USFS 2005).

A discussion of erosion following the Fork Fire and fire control activities is included in the section on water quality in Clear Lake in the 1999 Watershed Analysis Report. Accelerated rates of erosion were measured in chaparral areas, higher sediment and phosphorus loads were measured in stream water samples, and in January 1997, treatment plants in Lakeport, Nice and Lucerne were unable to adequately treat water due to high turbidity from the Forks Fire (LCWRD 1999, USFS 1999). USFS efforts to reduce erosion following the fire focused on stabilizing fire lines by creating waterbars and mulching in these areas.

13.4 Urban-Wildland Interface

Increasing numbers of people have moved into fire prone areas of California, termed the wildland-urban interface. Fire hazard is very high throughout almost the entire upper Middle Creek Watershed (Plate 14). Firefighters are better able to protect buildings in areas of more concentrated development, such as subdivisions, than buildings that are scattered more widely in the fire hazard zone. This is because they can better justify concentrating resources in these areas, and property owners can cooperate to set up effective fire breaks in and around these areas.

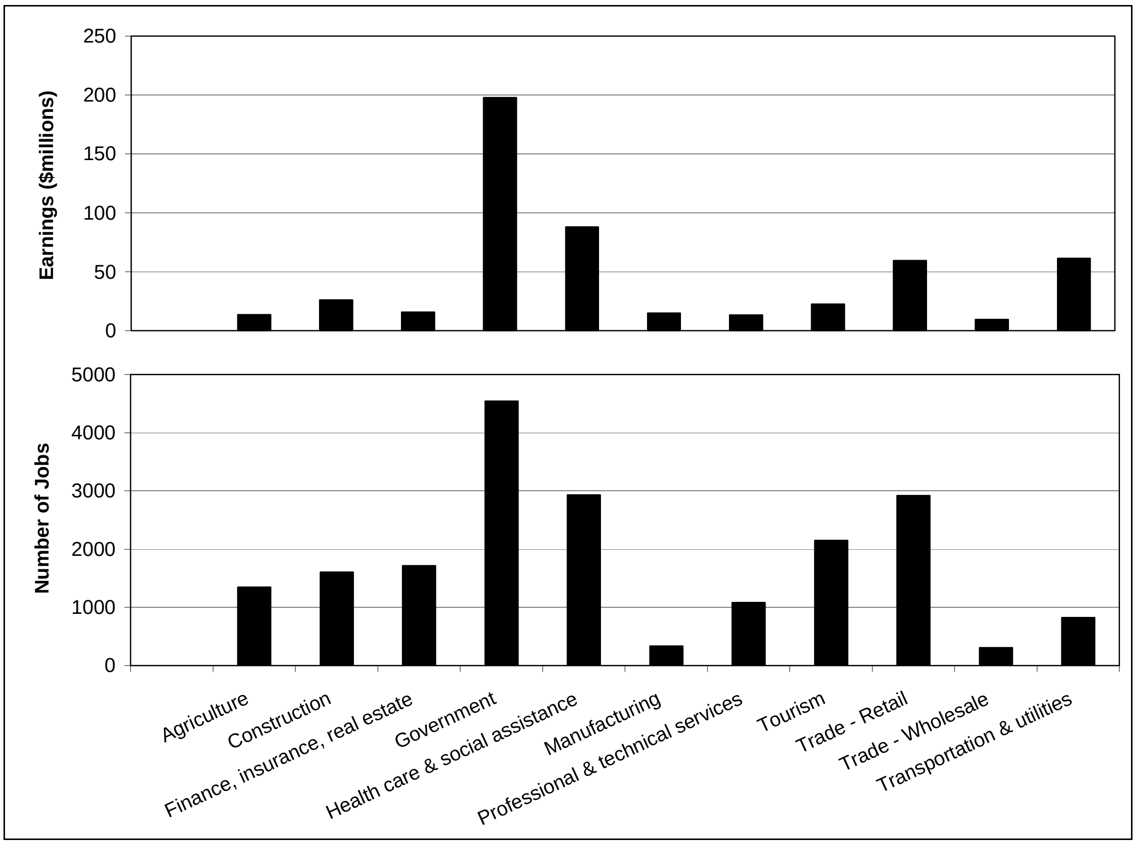
Upper Lake was identified as a Community at Risk in the Lake County Community Wildfire Protection Plan (CWPP) (ForEverGreen Forestry 2009). The town is described as having limited fuels in the historic town center, higher fuels in the interface and a wildfire threat from National Forest lands during extreme weather events. The CWPP also identified the need to increase water supplies for fire protection, including increasing water line capacity and storage in the Upper Lake water system, and the need to purchase additional water tenders.

There are many information sources on fire safety for homeowners in the urban-wildland interface (Appendix A). Clearing a defensible space free of highly flammable material around buildings is required by California law. Other ways to protect buildings include using less-flammable building materials and creating easy access for firefighters.

14.0 Social and Economic Setting

The only town in the Middle Creek Watershed is a portion of the town of Upper Lake. Economic activity in the watershed largely consists of agriculture and tourism, and many residents of the watershed work outside the watershed in Lakeport, Ukiah, or other areas. Major agricultural areas include Middle Creek and Clover Valleys. Important crops are pears, wine grapes, walnuts, wild rice, and hay. Livestock production is largely limited to cattle. Plate 15 shows where areas of human population occur in the Middle Creek Watershed. Population density is greatest in Upper Lake, intermediate in Middle Creek and Clover Valleys, and very low in the rest of the watershed.

There is no information on employment specific to the Middle Creek Watershed; therefore, information for the entire county is discussed here. The largest sources of employment in Lake County for both the number of jobs and earnings are government, health care, social assistance, and retail trade (Figure 14-1). Per capita income in Lake County in 2006 was $28,993, compared to $39,626 for California as a whole (BEA, USDC 2008). Because Lake County's median income is below the state median, local agencies and organizations are able to claim "disadvantaged community" status in many grant applications.



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Figure 14-1 Employment and earnings for the principal industries in Lake County, 2004.

Lake County's population is projected to grow approximately 15% each decade from 58,000 in 2000 to 107,000 by 2050 (State of California, Department of Finance 2007).

15.0 Land Use

15.1 Land Use Categories

Major land use categories in the Middle Creek Watershed are shown in Plate 16, and the area of each category is given in Table 15-1.

Table15-1. General Plan land use categories and areas in the Middle Creek Watershed.

Land Use Category	Area (acres)
Heavy Commercial/Industrial	6
Light Commercial	23
High Density Residential	162
Low Density Residential	654
Agriculture	2,429
Rural Lands	16,442
Tribal Lands (USA in Trust lands)	307
Public Facilities	5
Public Lands	28,711
Resource Conservation	1,197

Heavy Commercial/Industrial This category includes activities such as manufacturing, natural resource processing, research facilities, and "heavy" commercial activities. It includes uses such as large construction/contractor yards, warehouses, mills, automotive and equipment sales and services, and welding and fabrication yards (LCCDD 2008). There are 2 acres designated industrial in the Middle Creek Watershed, located on the Highway 20 corridor, west of Middle Creek.

Light Commercial This category includes local commercial, community commercial, and resort commercial land use designations. It includes businesses to meet local commercial, retail, and service needs such as general merchandise stores, hardware stores, restaurants, professional offices, and gasoline service stations. Light commercial land use is located in the town of Upper Lake (LCCDD 2008).

Residential High density residential areas have a density of 1-20 dwelling units per acre. In the Middle Creek Watershed they are found only in the town of Upper Lake. Low density residential areas have less than one residence per acre in a semi-rural setting. Low density residential development is found near Upper Lake and on Middle Creek.

Agriculture There are 2,429 acres designated as agriculture in the Middle Creek Watershed, comprising most of the level portions of Middle and Clover Creek valleys. Crops grown in this area include walnuts, wine grapes, pears, and hay. Agriculture is zoned with a minimum lot size of 40 acres in order to protect the county's agricultural resources and prevent development that would remove the land from agriculture. Agricultural lands "are actively or potentially engaged in crop production, including horticulture, tree crops, row and field crops, and related activities. Wineries and the processing of local agricultural products such as pears and walnuts are encouraged within this designation" (LCCDD 2008). Agricultural lands are also considered important for groundwater recharge and supporting the natural infrastructure of watersheds.

Rural lands are the second largest land use category in the Middle Creek Watershed, comprising 34% of the total watershed area. These are privately owned lands, primarily in their natural state. They are "remote, or characterized by steep topography, fire hazards, and limited access" (LCCDD 2008). Typical uses include animal raising, crop production, game preserves, and single family residences, and the minimum lot size is 20-60 acres depending on slope. These lands are important in groundwater recharge and supporting the natural infrastructure of watersheds. Many of the areas in rural lands in the Middle Creek Watershed have the potential for timber production.

Tribal Lands there are 307 acres of tribal lands owned by the Habematolel Pomo and Robinson Rancheria Pomo Indians in the Middle Creek Watershed.

Resource conservation lands are important for the maintenance of natural resources within the county including watershed lands that collect precipitation and lands important for groundwater recharge (LCCDD 2008). This land use designation is used primarily for areas along watercourses in the Middle Creek Watershed.

Public facilities areas are for services and facilities that are necessary for the community and natural environment. Typical uses include parks, schools, hospitals, and public utility facilities (LCCDD 2008). In the Middle Creek Watershed they include the Upper Lake Fire Station and the offices for MNF. The public schools in Upper Lake (with the exception of a portion of the Elementary School property) are outside the Middle Creek Watershed boundary. The area of public facilities in the Middle Creek Watershed is too small to be visible in Plate 16.

Public lands make up the largest area of the Middle Creek Watershed, covering 58% of the total watershed area. Almost all of this land is MNF land, and about 400 acres are BLM land. Because of the large proportion of the Middle Creek Watershed covered by MNF lands, management of MNF lands is covered in a separate section below.

15.2 Mendocino National Forest Land Management

MNF has forest-wide standards and guidelines for a full spectrum of resources and resource management issues including facilities and transportation; fire and fuels, forest health; range; recreation; riparian and aquatic systems; threatened, sensitive and endangered plants; timber and other forest products; watershed and water quality; and wildlife and fish. MNF also applies management prescriptions to specific areas "to attain multiple-use and other goals and objectives" (USFS 1995).

The majority of MNF land within the Middle Creek Watershed is in MNF management Area 2, which is named the Middle Creek Management Area (MCMA). Small portions of Management Areas 20 and 21 are also in the Middle Creek Watershed.

Wildlife habitat in the MCMA includes winter and summer range for deer, and mountain lion habitat. The east fork of Middle Creek provides good habitat for resident rainbow trout. The MCMA includes small areas of mature and old growth trees suitable for northern spotted owl and northern goshawk habitat. These areas are continuous with larger areas of mature and old growth tree habitat in adjacent management areas. Both management areas 20 and 21 are managed entirely with a late successional reserve management prescription, which is to provide habitat for species dependent on older, mature forested habitats. No sensitive plant species are known to occur in the MCMA (USFS 1995).

The MCMA experiences frequent wildfires that often start in lower elevation chaparral stands and potentially run uphill to timber stands. Management emphasizes fuels treatment within and adjacent to plantations. Extensive plantations in the Horse Mountain, Howard Mill area were established following the 1966 Round Fire (USFS 1995).

Primary recreational uses of the area are motorcycle riding, hunting, and hang-gliding. The management direction is to continue to emphasize OHV use. Existing trails are to be maintained, while non-system roads and trails are to be evaluated and obliterated or rehabilitated and added to the system.

The MCMA contains five management prescriptions. The largest is minimal management, followed by chaparral management, and wildlife emphasis (Table 15-2). Wildlife emphasis "is directed toward maintaining or increasing habitat capability for management indicator wildlife species" (USFS 1995). Chaparral is managed for a variety of objectives including wildlife, range, watershed, and fuels management. To achieve this, chaparral is managed to increase age class diversity, improve water availability for wildlife, and reduce risks of high intensity wildfires by breaking up large areas of high fuel loadings. Minimal management "maintains the existing the physical characteristics of the land through low intensity management. No regulated timber harvests are planned for these areas. Dispersed recreation is usually compatible with this prescription, and concentrated recreation use is unlikely" (USFS 1995). Late successional reserve provides for viability of the northern spotted owl and other species dependent on old growth forest ecosystems. Timber modified emphasizes timber production while providing for other visual objectives such as visual quality, watershed, rare species, and wildlife (USFS 1995).

Table 15-2. MNF management prescriptions and their areas in the Middle Creek Management Area.

Management Prescription	Area (acres)
Wildlife Emphasis	4,325
Chaparral Management	7,177
Minimal Management	15,174
Late Successional Reserve	100
Timber Modified	1,515

Source: USFS 1995

15.2.1 Timber and Vegetation Management

Timber harvest can contribute to soil erosion due to soil disturbance by heavy equipment, creation of roads, and removal of vegetative cover. The USFS designates riparian reserves along streams and rivers. In these reserves, timber harvest levels are reduced, and practices such as pile burning and prescribed fire are strictly limited. Riparian reserves vary in width depending on the type of stream; ephemeral, intermittent, or perennial. They include narrower equipment exclusion zones (Streamside Management Zones) adjacent to streams. Riparian reserves were first established with the 1994 Northwest Forest Plan, and they are intended to protect water quality and aquatic and riparian habitats, and to provide dispersal habitat for terrestrial animals. For timber harvest, vegetative manipulation, and fire suppression and fuels management, the USFS follows best management practices (BMP's) described in "Water Quality for National Forest System Lands in California Best Management Practices" (USFS 2000).

The following section on vegetation management, including timber harvesting and fuels treatments, was contributed by James Donahey, Planning Forester, MNF.

> Beginning in the mid-1960s, timber management focused on the utilization of timber products through intensive practices. This system of management involved harvesting what were believed to be dead or dying trees, removing competing vegetation, planting seedlings, post-planting treatments such as pre-commercial and commercial thinning, and even fertilizing and pruning the new trees to enhance the characteristics of the new stands.
>
> Two relatively recent events have had a large impact on the Middle Creek Watershed. These include the 1966 Round Burn and the 1996 Forks Fire. Both of these events had immediate consequences on the landscape, and the Mendocino National

Forest response influenced the long term effects of these events. The Forest Service response to these events involved the salvage of dead trees and the reestablishment of a new stand on the site to reduce erosion and restore habitat to forest dependent species. Much of the areas within these burns have had this series of treatments.

Including these events and other timber management projects, the Forest Service has performed many different timber focused treatments within the Middle Creek Watershed. These treatment methods, including both harvest and post harvest management actions, are selected by the District Silviculturalist. The intensity of the Silviculturalists' methods has varied over the years from the use of clearcuts to the selective harvesting of trees. Unfortunately, methods of reporting timber harvests have also changed, and some records have not been kept. For example, many of the areas reforested after the Forks Fire were probably salvage logged, but their harvest was not reported in the databases used today. Those treatments that occurred from 1965 to the present within the Middle Creek Watershed for which records do exist can be found in Table 15-3.

Table15-3 Harvest method acreage by year for the Middle Creek Watershed.

Harvest Method		Year	Acres
Clearcut		1983	135
	Total		**135**
Commercial Thinning			
		1987	76
		2007	194
	Total		**270**
Overstory Removal			
		1988	5
	Total		**5**
Salvage			
		1988	5
		1989	36
		1992	333
		1993	0
		1998	63
		2000	2
		2001	34
	Total		**473**
Shelterwood			
		1989	5
	Total		**5**
Single Tree			
		1965	11
		1988	1
	Total		**11**
	Grand Total		**899**

As of December 2008, USDA Forest Service records report 1,678 acres of plantations within the Middle Creek Watershed. Timber harvests in the mid-1980s and early 1990s resulted in 83 acres of plantations. Nearly 1,000 acres of plantations were post-wildfire reforestation treatments from the Round Burn in 1966 and the Forks Fire in 1996. Plantations from the Round Burn were planted between 1966 and the late 1980's, while plantations from the Forks Fire were planted between 1997 and 2004. An additional 600 acres listed in the Mendocino National Forest records without a reported event is also likely attributable to these two fires or perhaps smaller fires such as the 1981 Hunter fire.

Timber management projects that have been prepared since 1998 within the watershed boundary have been in response to the Forks Fire or as part of a fuel reduction project in the reforested areas following the Round Burn. Some of these projects involved salvaging burned timber, thinning overly dense stands, or reforesting burned areas. By year, these projects can be found in Table 15-4.

Table 15-4 Timber and fuels management projects within Middle Creek Watershed.

Timber/Fuels Project		Year	Acres
Crabtree Fire Salvage		1998	137
	Total		137
East Fork Riparian Reserve		2000	4
		2002	87
	Total		91
East Fork Salvage		1998	250
		2001	8
		2002	136
	Total		395
Elk Mountain Fuel Break		2008	680
	Total		680
High Horse Stewardship		2007	295
	Total		295
Mary Anne Fire Salvage		2000	23
	Total		23
	Grand Total		1620

The quantity of timber products sold in or near the Middle Creek Watershed reveals that some of the projects that were prepared were not completed. Following the Forks Fire in 1996, salvage volumes were 8,185 CCF[20] in 1997, 22,071 CCF in 1998, and 328 CCF in 1999. Salvage sales after 1999, including the later East Fork, East Fork Riparian, and the Mary Anne fire salvage were not completed. Unfortunately, it is not possible to determine how much of the completed salvage sale products came from the Middle Creek Watershed or from neighboring watersheds within the Forks Fire boundary. Aside from salvage logging following the Forks Fire, the only other project within the watershed boundary to yield timber products was the High Horse Stewardship, in which 2,913 CCF of timber was sold from thinned plantations within the Round Burn.

The use of prescribed fire to restore historical fuel conditions to these fire dependent ecosystems is yet another management tool. Records since 2000 show that broadcast burning, pile burning, and under-burning have been heavily utilized within the watershed to reduce the risk of high intensity catastrophic wildfires, Table 15-5. These projects include the High Horse Stewardship, Streeter Ridge Pile Burn, Howard Mill Understory Burn, and the Elk Mountain Fuel Break.

Table 15-5 Prescribed fire use by year and type

Prescribed Fire Type	Year	Acres
Broadcast Burning	2002	150
	2004	200
Total		**350**
Pile Burn	2006	380
	2008	380
Total		**760**
Under Burning	2000	450
	2001	20
	2003	390
	2004	460
	2005	120
	2007	270
	2008	890
Total		**2,590**
Grand Total		***3,690***

Future Projects

Project planning involves a four year planning horizon. As of December 2008, there are two new projects in the planning stages intended to reduce the risk of catastrophic wildfire to both the Mendocino National Forest and the surrounding communities. These projects include the Lakeview Wildland Urban Interface (WUI) fuels reduction project tentatively scheduled for 2011 and the Garrett Mountain Late Successional Reserve (LSR) fuels reduction project scheduled for 2013. These projects will focus on reducing ladder fuels and restoring forest canopies to a more open condition.

The proposed treatments within the Lakeview WUI project will reduce the risk of high intensity catastrophic wildfires either moving from the forest into the community of Lucerne, or from the community of Lucerne into the forest. Fires that do occur after the completion of this project will be less likely to grow from low intensity surface fires to high intensity canopy fires.

Similarly, the Garrett Mountain LSR fuels reduction project will probably follow a similar treatment design with a different focus. Instead of protecting a community, the project is intended to protect and enhance the habitat of the Northern Spotted Owl. Likely treatment selection will reduce ladder fuels and open the canopy to prevent catastrophic stand replacing wildfires from reducing designated late successional habitat on the Mendocino National Forest. Additionally, in areas of the reserve that are not currently suitable habitat for the Northern Spotted Owl, proposed treatments will be designed to speed the development of late successional habitat.

Precise treatments and treatment areas for both projects have not been decided at this time, but are likely to include elements of both mechanical removal of standing trees and the use of prescribed fire to consume hazardous fuels currently within the treatment areas. No other treatment areas have been designated within the Middle Creek Watershed at this time, but if a catastrophic wildfire or other unintended event should occur, the Mendocino National Forest will be ready to respond appropriately to the concerns of the public and to achieve our management objectives.

Figure 15-1 Plantation that has recently been under-burned.
Photo by Greg Dills taken April 13, 2009.

Although the above section documents significant areas where pile and under-burning has been conducted since 2000, the area of prescribed burning in chaparral is less than that recommended in the 1999 Watershed Analysis Report. According to that document, "The Forest goal for chaparral is to bring suitable chaparral lands under management to capture potential range, wildlife, recreation, and watershed benefits, and to reduce the risk of large costly wildfires." With an area of 7,177 acres in chaparral management prescription in the watershed, and a goal of burning 5% of it annually, 359 acres per year should be burned according to the 1999 Watershed Analysis Report (USFS 1999). Only 350 acres have been broadcast burned since 2000 (Table 15-5 above). This may be in part due to the extent of chaparral burned in the Fork Fire in 1996. However, the 1999 Watershed Analysis Report documents 3,090 acres burned between 1975 and 1996, or about 150 acres per year.

15.2.2 Grazing Management

There are currently two grazing allotments on MNF land in the Middle Creek Watershed that allow grazing for 160 head of cattle between May 15 and October. Grazing allotment permittees pay fees based on the number of cattle and months of grazing, and they are responsible for maintenance of improvements. USFS personnel monitor grazing use and meet annually with permittees. Permits are subject to environmental review under the National Environmental Policy Act (NEPA) every 10 years when they come up for renewal. Historic grazing levels in the area were greater than current levels. In 1949 there were 3-400 head of cattle grazed over longer periods of time during the year (Lori Wright, personal communication).

15.2.3 OHV Recreation

OHV use is a very popular form of recreation on MNF lands in the Middle Creek Watershed. The Middle Creek Campground, located at the confluence of the east and west forks of Middle Creek (Plate 2), is the main staging area for OHV trails in the Middle Creek Watershed and farther north in MNF. There were 5,000 campground users in 2008, and an estimated 80% of this use was for OHV recreation visitors. The majority of visitors come from Santa Rosa and the San Francisco Bay area, and the majority of OHV use occurs between the months of October and June. (Lori Wright, personal communication).

There is an open riding area adjacent to the Middle Creek Campground approximately 1 acre in size. To protect Middle Creek from damage by OHV use, 7,500 square feet of the open riding area adjacent to the west fork of Middle Creek was closed to OHV use in 2008. OHV use occurs in the channel and floodplain of the east fork of Middle Creek, and thus far USFS personnel have been unable to develop alternate routes that prevent this use. There are 7 miles of OHV trails within MNF lands in the Middle Creek Watershed, including two steep, advanced trails that climb from the east fork of Middle Creek to provide access to trails for intermediate and novice riders at the top of the watershed, and north in the Eel River watershed.

The two advanced trails are maintained annually by USFS crews and less steep, short trails near the Middle Creek Campground are maintained every other year (Mike Burman, personal communication). The 1999 Watershed Analysis Report found that unauthorized OHV use in stream channels and erosion from OHV trails contributes sediment to Clear Lake. MNF Westside hydrologist Frank Aebly finds that maintained trails in the MNF OHV system are not likely to be major contributors to sedimentation; however OHV use on unauthorized trails may be a more serious problem (Frank Aebly, personal communication).

15.2.4 Road Maintenance and Construction

Most older roads in MNF and adjacent private lands are designed so that water drains into ditches on the in-slope of the road and is channeled into natural draws, culverts, or bridges to cross the road. This design increases storm run-off and transfer of sediment from roads to streams. New roads are being designed with out-sloping and rolling dips for drainage, which helps to disperse run-off across the hill slope (USFS 1999). However, even better-designed roads require periodic maintenance. The 1999 Watershed Analysis Report found that poorly designed public and private roads are contributing to sedimentation, and the road system in the watershed is continuing to decline due to insufficient funding. This situation has changed very little since 1999, as funding continues to be inadequate. Currently, the permanent MNF road crew is a two man crew with one backhoe. They are responsible for maintaining the 3-400 miles of road on the nearly 1,000,000 acres of MNF land. Additional funding is found through government programs as it becomes available (Bruce Smith, personal communication).

In 2009, a MNF forest hydrologic technician inventoried road conditions, focusing on stream courses that are tributary to Middle Creek. These inventories will assists with prioritizing projects to improve road drainage and/or decommissioning. MNF is applying for FY 2010 Legacy Road Maintenance funding for some or all of the roads identified in the survey.

Figure 15-2 Eroding road surface on MNF lands. (This area was burned by the 1996 Fork Fire.) *Photo by Greg Dills taken April 13, 2009.*

<u>15.3 Illegal Marijuana Cultivation</u>

Illegal marijuana growing operations in the upper watershed may have substantial localized impacts on watershed health. Lake County has had the highest number of plants seized by the state’s Campaign Against Marijuana

Production, (CAMP), from 2006-2008. In 2008, 500,000 plants were seized in Lake County, mostly from public lands. Marijuana growing operations frequently rely on water diversions from streams and may significantly de-water small streams during summer months. At times, ponds are built adjacent to streams for fertilizer mixing and cause both sediment and fertilizer inputs to streams (Figure 15-3). Diesel spills from generators used to power pumps or other equipment have also contaminated waterways, and trash and irrigation equipment lead to considerable clean up costs (Anderson 2008, Edmison 2007).

Figure 15-3 Fertilizer mixing pond for marijuana growing located on BLM Cow Mountain land (adjacent to Middle Creek Watershed).
Photo courtesy of Gary Sharpe, Ukiah BLM

16.0 Current Watershed Management

This section briefly summarizes the agencies and organizations responsible for regulating, managing, and providing assistance with different aspects of watershed management.

16.1 Soil Conservation

The Lake County Grading Ordinance (LCCDD 2006) establishes standards for grading and erosion control plans based on project size and soil erosion hazard. The Lake County Community Development Department (LCCDD) is responsible for enforcing compliance with the ordinance. The Natural Resources Conservation Service (NRCS) is a branch of the USDA with an office in Lakeport. They provide technical assistance on conservation of soil, water, and other natural resources and have programs for cost-sharing on selected conservation measures.

16.2 Water Quality Protection

The Lake County Division of Environmental Health administers regulatory programs that include components designed to protect drinking water quality. These include permits, inspection, and enforcement for water well installation, small public drinking water systems (having 5 to 14 connections and serving fewer than 25 people daily over 60 days of the year), on-site septic sewer systems, underground storage tanks, hazardous material disposal, and solid waste facilities.

Regulation of large public drinking water systems is by the California Department of Public Health. The California Drinking Water Source Assessment and Protection Program requires large public drinking water systems to complete a drinking water source assessment that includes an inventory of possible contaminating activities and a vulnerability ranking to potential contamination (CDHS 1999).

Wastewater discharges from wastewater treatment plants are regulated by the CVRWQCB through WDR permits. Only discharges to land or for underground injection at the Geysers are allowed, and WDR permits specify the conditions for the discharges. The CVRWQCB issues cease and desist orders to enforce improvements related to spills.

The Lake County Clean Water Program is charged with controlling pollution from urban and other storm drains. To comply with federal mandates for storm water pollution prevention, the LCCDD manages this program in cooperation with the cities of Lakeport and Clearlake. The CVRWQCB oversees compliance with this program. LCCDD also ensures compliance with the newly updated Lake County grading ordinance.

The Sacramento Valley Water Quality Coalition monitors stream water quality and promotes agricultural best management practices locally and throughout the Sacramento River watershed to comply with CVRWQCB requirements to reduce non-point source pollution from irrigated agriculture.

Clear Lake is impaired for both nutrients and mercury under Section 303(d) of the Federal Clean Water Act. This required the CVRWQCB to work with the county and other entities to develop the pollution control plans, TMDL's, for these contaminants. A monitoring and implementation plan for both the Clear Lake Mercury and Nutrient TMDL's was submitted in October 2008 by the Clear Lake TMDL Stakeholder Committee (CLTSC), comprised of government agencies involved with land and resource management in the area; the County of Lake, Bureau of Land Management and USFS; the Bradley Mining Company (owner of the Sulphur Bank Mine) in the case of the mercury TMDL; and the Lake County Irrigated Lands Watershed group in the case of the nutrient TMDL. The CLTSC goals are:

A. Control: Combine resources to achieve required mercury and nutrient load reductions and to eliminate the impairment of the beneficial uses of Clear Lake.

B. Information Exchange: Share information regarding best management practices, monitoring data, and methods.

C. Cooperation:
   1. Develop and implement a plan to reduce the input of mercury and reduce the mercury concentrations in the lake sediments.
   2. Develop and implement a plan to collect the information needed to determine what factors are important in controlling nuisance algae blooms and to recommend what control strategy should be implemented (CLTSC 2008).

The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project) will significantly improve Clear Lake water quality by reducing total sediment and phosphorus inputs to the Upper Arm of Clear Lake by approximately 28% (USACE 1997). The LCWPD has been pursuing this project since 1995, and when funded, the project will acquire 1,650 acres of land and breach the levees to allow the land to flood. This will restore approximately 1,400 acres to wetlands and open water.

An update of the Lake County General Plan and an accompanying Environmental Impact Report (EIR) were approved in September 2008 (LCCDD 2008). The General Plan recognizes water quality issues and regulatory requirements with the goal of protecting surface and groundwater quality. Implementation will include a review process of proposed developments to evaluate potential contaminants and verify compliance with regulatory requirements such as the National Pollutant Discharge Elimination System (NPDES), stormwater, and TMDL programs. The county will monitor and work with industries that may discharge pollutants to surface waters, ensure compliance with current regulations, and reduce wastewater discharges. Through the Grading and Stormwater Ordinances, the county will "ensure that erosion control measures are utilized during construction and post construction." The county will "attempt to inventory watersheds that drain into Clear Lake and identify those which carry high levels of pollutants and those that have high sediment yield" in order to prioritize them for restoration and management (LCCDD 2008).

16.3 Streambed, Lake and Wetland Alterations

Activities in streams, lakes, and wetlands such as debris removal, restoration projects, or stabilization structures may require permits and environmental review from a variety of agencies. A first step is often to contact the DFG which requires notification for any activity that will:

- “Substantially divert or obstruct the natural flow of any river, stream, or lake;
- substantially change or use any material from the bed, channel, or bank of any river, stream, or lake; or
- deposit or dispose of debris, waste, or other material containing crumbled,flaked, or ground pavement where it may pass into any river, stream, or lake.

> The notification requirement applies to any work undertaken in or near a river, stream, or lake that flows at least intermittently through a bed or channel. This includes ephemeral streams, desert washes, and watercourses with a subsurface flow. It may also apply to work undertaken within the flood plain of a body of water” (DFG 2008).

If DFG finds that “the activity may substantially adversely affect fish and wildlife resources,” then a Lake or Streambed Alteration Agreement is necessary as required in Section 1602 of the Fish and Game Code.

Placement of structures or dredged or fill materials in waters of the United States[21] requires a Section 404 permit from the USACE and Section 401 Water Quality Certification from the RWQCB. In addition, the state of California requires a permit for discharge into “isolated” waterbodies (EPA 2007, SWRCB 2008).

16.4 Water Infrastructure and Supply

The Lake County Groundwater Management Plan (CDM and DWR 2006c) provides guidance on managing groundwater resources. Objectives of the Lake County Groundwater Management Plan include maintenance of a sustainable high quality water supply for agricultural, environmental, and urban uses, facilitation of projects to replenish groundwater, and improved understanding of groundwater resources.

The Lake County General Plan states several goals with regard to ensuring water availability (LCCDD 2008). Goal WR-3 is “to provide a sustainable, affordable, long-term supply of water resources to meet existing and future domestic, agricultural, industrial, environmental, and recreational needs within the county, so as to maintain sustainability between new development and available water supplies”. Implementation measures include designating and managing groundwater recharge areas, managing groundwater resources

[21] Waters of the United States includes “All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including…tributaries of all waters mentioned above” (SRWP 2008).

to ensure sustained yields, working with public agency water providers and local stakeholders to develop groundwater management partnerships, identifying critical water resource areas, and participation in local, state, and regional water resource planning efforts.

16.5 Flood Management

The Lake County Water Resources Division in the LCPWD is responsible for flood management and updates the floodplain management plan. Lake County participates in the NFIP which was established in 1968 to provide flood insurance to property owners in return for community floodplain management regulations to reduce future flood damage potential. Lake County has a qualifying floodplain management plan, and therefore, Lake County residents can purchase flood insurance under the NFIP (Lake County 2000, FEMA 2002).

Flood hazard is addressed under the Draft Lake County General Plan Goal HS-6 "to minimize the possibility of the loss of life, injury, or damage to property as a result of flood hazards." In 1% flood chance zones, General Plan policies allow passive recreational activities such as hiking and horseback riding, prohibit the development of critical facilities, and require other developments to minimize flood risk to structures and infrastructure (LCCDD 2008).

Passage of a benefit assessment by property owners created Flood Control Zone 8 in 2000 to pay for the operation and maintenance costs of the Upper Middle Creek Flood Control Project by the LCWPD. The project includes 11 miles of levees on Scotts, Middle, Alley, and Clover Creeks and a flow diversion structure on Clover Creek. Maintenance includes mowing levees, spraying vegetation, adding gravel to the levee roads, and removing brush and gravel from the flood control channels above the confluence of Middle and Scotts Creeks.

Maintaining clear stream channels helps maintain flow capacity and reduce flood potential. The Lake County Sheriff's Office of Emergency Services website urges property owners to "remove debris, such as trash, loose branches, and vegetation growing in the stream channel" (LCS 2008). At the same time, stream channel alterations may require approval by agencies such as the DFG, USACE, and LCCDD (Section 16.3).

16.6 Wildlife and Habitat Protection

The United States Fish and Wildlife Service (USFWS) administers the Endangered Species Act to protect species and the ecosystems on which they depend. They carry out scientific studies and list species as "threatened" or "endangered". Once species are listed as endangered, trafficking in the species is prohibited, and critical habitat for the species is protected. The

USFWS also has a Division of Migratory Bird Management to conserve migratory birds and their habitats.

DFG is the lead agency for fisheries and wildlife management in the state. A description of the agency's role from their website reads:

DFG maintains native fish, wildlife, plant species, and natural communities for their intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance in a sufficient amount and quality to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific, and educational uses.

The California Fish & Game Commission adopts fishing and hunting regulations and guidelines for determining whether species have California endangered or threatened status. With respect to non-game species, DFG manages species of special concern to achieve conservation and recovery before they require California Endangered Species Act listing.

In addition to the potential increase in wetlands under the Middle Creek Project (Section 17.2), DFG recently completed a Clear Lake Wildlife Area (WLA) Conceptual Area Protection Plan (CAPP) that would include the Middle Creek Project, current DFG and Land Trust lands to the south of Rodman Slough, additional land to the south of the Middle Creek Project, and a large portion of Tule Lake to total approximately 3,225 acres. The Clear Lake WLA would include riparian, wetland, open water, and oak woodland habitats. However, once restored, over half of this area would be wetland habitat. The purpose of land acquisition for the CAPP is "the conservation, protection, and restoration of significant wetland and upland habitats and their associated species in one of the few remaining natural areas on Clear Lake" (DFG 2008). This project could provide valuable habitat for a variety of sensitive species including the Northwestern pond turtle, foothill yellow-legged frog, California red-legged frog, tri-colored blackbird, double-crested cormorant, osprey, and bald eagle. The area is an important stopover for songbirds and supports cover for numerous waterfowl and water birds.

The Lake County General Plan goal with respect to wildlife is "to preserve and protect environmentally sensitive significant habitats, enhance biodiversity, and promote healthy ecosystems throughout the county" (LCCDD 2008).

16.7 Fisheries and Aquatic Habitat Protection

As stated in Section 16.6, DFG enforces fishing regulations. They also enforce environmental laws with regard to streambed alterations and potential pollution of waterways due to spills and other illegal discharges.

The DFG 2000 Clear Lake Fishery Management Plan has the objectives "to maintain and enhance fishery resources and the habitats upon which they depend, and provide and where possible, improve fishing opportunities." DFG issues permits for bass fishing tournaments and commercial fishing on Clear Lake and enforces compliance with these permits. DFG also regulates sport fishing through the issuance of licenses and enforcement of fishing regulations (DFG 2008b).

A local CRMP group, the Chi Council, is dedicated to watershed and lake management to improve populations of the Clear Lake hitch. Members include representatives of conservation groups, local Tribes, local, state, and federal resource agencies, and concerned citizens. The council organizes volunteer monitoring of spawning runs, encourages scientific research on the hitch, gathers information about the hitch and their uses by native peoples, and sponsors habitat restoration. Local Tribes have programs to monitor hitch spawning runs and stream conditions, and they are preparing an adaptive management plan for the hitch.

16.8 Integrated Regional Water Management Plan

The IRWMP is an important planning effort related to numerous aspects of watershed management including both surface and groundwater supplies. The proposed planning area for the IRWMP that will encompass the Clear Lake Watershed is comprised of the Cache and Putah Creek Watersheds as well as most of the remaining area of Yolo County. The tentative name for the region is the Westside Region. Participating governments/agencies are; Lake, Napa, Yolo, and Colusa Counties and the Solano Water Agency.

The IRWMP will promote a regional and integrated approach to water management and will foster coordination, collaboration, and communication among agencies and organizations responsible for water-related issues. The plan will cover providing water supply reliability, water recycling, water conservation, water quality improvement, stormwater capture and management, flood management, recreation and access, wetlands enhancement and creation, and environmental and habitat protection and improvement. The IRWMP is intended to provide a comprehensive approach to addressing water supplies as a component of the California Water Plan.

Stakeholder meetings for the IRWMP involving Lake County residents, agencies, and organizations began in May 2007. The meetings have gathered input on Lake County priorities, goals, and objectives for the IRWMP. Currently meetings are being held among the cooperating agencies. Lake County is in the process of finalizing goals and objectives (by the end of 2009) to be included in the IRWMP. By the first quarter of 2010, the Lake County contribution for a planning grant application will be completed. The goal for completion of the IRWMP is the end of 2012.

16.9 Prevention, Eradication and Control of Invasive Species

The US Fish and Wildlife Service has numerous mandates for prevention and control of invasive species. Under the Lacey Act, it regulates the " importation and transport of species, including offspring and eggs, determined to be injurious to the health and welfare of humans, the interests of agriculture, horticulture, or forestry, and the welfare and survival of wildlife resources of the U.S. Wild mammals, wild birds, fish, mollusks, crustaceans, amphibians, and reptiles are the only organisms that can be added to the injurious wildlife list (USFWS 2008)." The National Invasive Species Council is a council of 13 federal departments that deal with invasive species. It was created in 1999 by Executive Order 13112 "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause" (USDA 2008).

In California, CDFA is charged with prevention of importation of pests and diseases and control of pests within the state. CDFA works in cooperation with the state DFG and the USDA. CDFA focuses on prevention of invasive plants, insects, and diseases of plants and livestock. DFG focuses on invasive animals including the quagga and zebra mussels. CDFA's exclusion branch includes inspection stations on major highways entering the state and enforcement of quarantines and inspection of packages at parcel carrier terminals within the state. CDFA also provides oversight of nurseries in California (CDFA 2008b). Once finalized, a new amendment to Section 3060.3, Title 3 of the California Code of Regulations will make it illegal for plants classified as noxious weeds to be sold as nursery stock.

CDFA has a program to eradicate hydrilla in Clear Lake and other water bodies in the state. The Clear Lake program, headquartered in Lakeport, has crews that survey the lake and apply herbicides to control hydrilla from April through mid-October. The number of boat crews has increased from three in 2007 to four in 2008, and it will be five in 2009 (CDFA 2007, Patrick Akers personal communication).

Many CDFA activities are carried out by county Agricultural Commissioner offices. In Lake County, the Agriculture Department has trapping programs for Japanese beetle, Mediterranean, Mexican, melon and oriental fruit flies, the glassy-winged sharpshooter, vine mealybug, light brown apple moth, and gypsy moth. They have programs to eradicate skeleton weed and to prevent the spread of leafy spurge. They also carry out control of scotch thistle and purple star thistle depending on the availability of funding. LCAD also carries out inspections of packages to local carriers, and plant shipments to local nurseries (Steve Hajik, personal communication).

The LCWMA, formed in 2001, is a group that cooperates and coordinates activities and expertise to prevent and control weed problems in Lake County.

It is made up of the Lake County Agricultural Commissioner's office, the LCPWD, the East and West Lake RCD's, and the local office of NRCS, with many other governmental agency, tribal, environmental, and industry groups as partners. Its activities are "focused upon the exclusion, detection, suppression, and eradication of noxious and invasive non-native weeds" (LCWMA 2008).

16.10 Fire Hazard Management

Within the boundaries of MNF, the USFS is responsible for wildland fire protection and protection of MNF buildings. The MNF boundary follows the outer extent of USFS land and encloses private properties that fall within this outer boundary (Plate 16). The Northshore Fire Protection District is responsible for all structure fires within its boundary, and for private structure fires in MNF. Northshore Fire Protection District boundaries include Upper Lake, Middle Creek and Clover Valleys, and the area surrounding the main stem of Middle Creek. CAL FIRE is responsible for fighting wildland fires within the Northshore Fire Protection District.

A community wildfire protection plan (CWPP) for the entire county was completed in August 2009 (ForEverGreen Forestry 2009). Local, state, and federal fire protection organizations and other interested parties were involved in developing and reviewing the plan. The plan includes sections on wildfire behavior, fire ecology, Lake County community features, fire protection organizations, risk assessment, and an action plan. The action plan includes sections on advancing defensible space, reducing fuels and structural ignitability, enhancing fire protection, evacuation planning, and fire safe education.

Several first priority (0-5 year timeframe) fuel reduction projects were identified by the CWPP in and adjacent to the Middle Creek Watershed (ForEverGreen Forestry 2009). These projects include the Elk Mountain fuelbreak, the Hogback Ridge shaded fuelbreak, the Pitney Ridge shaded fuelbreak, and a fuel break from High Glade to High Valley.

In January 2009 Lake County provided temporary funding for a Fire Safe Coordinator whose duties will be to implement the CWPP and assist local communities in becoming Firewise Communities. By joining together in Firewise Communities neighbors can create a much more effective defensible space around their community. The Firewise Community website also offers excellent education for homeowners (Appendix A).

The Lake County General Plan includes goal HS-7 "to minimize the possibility of the loss of life, injury, or damage to property as a result of urban and wildland fire hazards". Policies to reach this goal include support of fuel reduction programs, requiring wildland fire management plans for projects adjoining areas that may have high fuel loads, fuel break requirements, and specific development guidelines for lands designated as high and extreme wildfire hazards (LCCDD 2008).

The state of California requires anyone owning, leasing, or otherwise responsible for buildings in wildfire hazard areas to maintain a defensible space around the building. (See Appendix A for resources on defensible space.) CalFire inspects new buildings for compliance with defensible space requirements, and they inspect other buildings when they receive complaints and when time permits (Jim Wright, personal communication).

Landowners wishing to carry out prescribed burns should contact the Lake County Air Quality Management District and CAL FIRE. CAL FIRE can provide technical advice on prescribed burning, and in some instances, when a large area of brushland is involved, CAL FIRE can cost share and provide expertise for prescribed burning.

16.11 Prevention of Illegal Dumping

Lake County combats illegal dumping in several ways. The Lake County Public Services Department (LCPSD) has contracted with two private franchise haulers to provide low cost curbside trash pick-up and recycling. The county also sponsors a free mobile household hazardous material program that is available to residents about once a month to dispose of paint, chemicals, small propane tanks, fluorescent lights, and unusable over-the-counter or prescription drugs.

LCPSD, and the Code Enforcement Division (CED) of LCCDD, have a prevention program that encourages residents to use low cost or free disposal and amnesty programs. They educate the public about low-cost/no-cost options for waste disposal through such means as brochures, flyers, a recycling website, newspaper articles, and radio announcements. Enforcement is another approach to prevention. The penalty for illegal dumping (a misdemeanor) is a fine of up to $100 and up to 30 days in jail, or both. Complaints can be reported to CED, (707) 263-2309 or to their 24 hour hotline, (707) 263-2308.

Illegal waste clean-up on private property is enforced by CED. They also apply for grant funding to clean up illegal dumpsites. For example, they received $35,000 to clean up 17 illegal dumpsites in the county in 2007-2008. When clean-ups involve a health and sanitation issue, Environmental Health Division (EHD) is involved. EHD has funding for clean-up of drug lab chemicals. They have grant funding to ensure that local businesses properly dispose of tires, and this funding includes some money for clean-up of illegally dumped tires.

CED, EHD, and the Lake County Sheriff's Department investigate reports of illegal dumping. Enforcement is difficult, due to a lack of state guidance on what constitutes sufficient evidence to prove that illegal waste disposal has occurred. Therefore, the Sheriff's Office gets involved when there is prosecutable evidence, such as an eyewitness to the illegal dumping. The DFG enforces state law that prohibits dumping within 150 feet of a water body. The state number to report illegal dumping is (888) DFG-CALTIP. This number is to report both poachers and polluters, and if the reported information leads to an arrest, the reporter is eligible for a reward.

16.12 Land Use Planning

The Lake County General Plan is a comprehensive and long range general plan for the county's development as required by state law. The first land use goal of the Lake County General Plan is to encourage economic and social growth in the county while maintaining quality of life (LCCDD 2008). In part, this is to be done by clearly differentiating "between areas within Lake County appropriate for higher intensity urban services and land uses (i.e., high density residential, high density commercial, and industrial) from areas where rural or resource use should be emphasized".

The Lake County Zoning Ordinance establishes specific districts (for example agricultural, rural residential, and resort commercial districts) and the standards for land use and construction in those districts. LCCDD prepares updates to the County General Plan and to area plans (for example the Upper Lake/Nice Area Plan). They are responsible for enforcing compliance with the zoning ordinance.

The Planning Commission is an unpaid board of five members, each appointed by the supervisor in their district for a two year term. Their duties are to hold public hearings on proposed zoning, to hear and decide permit applications and applications for variances, to consider maps of proposed subdivisions, and to investigate and make recommendations to the Board of Supervisors with regard to public projects and acquisitions.

16.13 Cultural Resource Management

Potential cultural resources are identified when projects require initial inspection under California law (California Environmental Quality Act, CEQA sec. 15064.5, 15065 a, 21083.2, 21084.1). The historical or archeological resource comes under the protection of CEQA if it is significant or unique enough to be included in the California Register of Historic Resources including that it:

> (1) Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage.
>
> (2) Is associated with the lives of persons important in our past.
>
> (3) Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values.
>
> (4) Has yielded, or may be likely to yield, information important in prehistory or history. (CEQA sec. 15064.5)

The first phase of inspection is a background record search and inspection of the site by a qualified archeologist. In some cases, a small test excavation is necessary to determine the significance of the cultural resource.

When a unique archeological resource is found, CEQA requires the agency involved to first consider alternatives that preserve the resource in place and in an undisturbed state. Additional regulations apply if the resource cannot be left in place (CEQA sec 21083.2). When the inspection finds the existence or probable existence of Native American remains within the project, the permitting agency must work with the appropriate Native Americans as identified by the Native American Heritage Commission. Accidental discovery of human remains requires determination by the county coroner as to whether they are Native American and contact of the Native American Heritage Commission if they are. Agreements are then made for "treating or disposing of, with appropriate dignity, the human remains and any associated grave goods" (CEQA section 15064.5).

Impairment to historical resources can be mitigated to a non-significant level by following federal guidelines for preservation and restoration of historic properties or by other measures identified by the permitting agency (CEQA sec 15064.5).

16.14 Watershed Education

In many cases the regulatory and management agencies mentioned above are excellent sources of information to watershed users. In addition, some government agencies have the primary mission of technical assistance and education. The NRCS, with an office in Lakeport, provides technical and financial resources to landowners in areas such as soil conservation, wildlife habitat improvement, range and forest land improvement, and sustainable agriculture. The University of California Cooperative Extension office in Lakeport also provides education and technical resources in these areas.

17.0 Findings and Recommendations

17.1 Current Watershed Conditions for Identified Issues

17.1.1 Protecting Water Quality

High sediment loads can smother gravel beds and other important aquatic habitat components. Sediment contributes nutrients to stream systems, and sediment is the leading source of excess nutrients to Clear Lake. Anecdotal evidence indicates that sediment loads may be greater from the east than west fork of Middle Creek. MNF is completing a road and trail survey that will assist with prioritizing projects to improve road drainage and decommissioning in the Middle Creek Watershed. While most of the mountainous terrain in the Middle Creek Watershed is in MNF, a survey on the condition of county and private roads in the upper watershed is also needed. Surveys are needed to determine what additional factors contribute to erosion and sedimentation in the Middle Creek Watershed, and whether there are sub-watershed differences. Other factors potentially contributing to sediment loads in Middle Creek include inherent differences in soils, geology, aspect, and vegetation, or differences in the impacts from human activities such as OHV use, road construction and maintenance, and fire and fuel load management.

Several areas have been identified where there are unstable stream channel conditions and significant streambank erosion. OHV travel occurs in and adjacent to the channel of Middle Creek in the area of the confluence and upstream approximately 2 miles on the east fork. Eliminating OHV travel in the channel, and re-routing trails to prevent damage to streambanks and riparian vegetation are needed in this area. Middle Creek below the confluence is another area with significant streambank erosion. It is discussed in Section 17.1.6 below.

Stream channel conditions in the East Fork of Middle Creek have not been surveyed since 1982, and most other stream channels in the upper watershed have not been surveyed.

Studies of potential toxic pollutants of surface waters in the Middle Creek Watershed have been very limited. A monitoring program by the LCWPD did not find elevated mercury levels in the watershed. Sampling for pesticides on three dates detected only one exceedance for DDT. DDT is a pesticide that persists in soil but has been banned in the United States for 37 years.

Groundwater has been sampled by DWR on an infrequent basis since the 1940s. Primary drinking water standards to protect public health were exceeded twice for arsenic and once for barium. The presence of these two elements is likely to be due to natural geologic and hydrologic conditions. These exceedances highlight the importance of testing private drinking water wells for potentially dangerous constituents.

17.1.2 Ensuring Water Availability

Most water use in the Middle Creek Watershed is from groundwater aquifers, especially those in Middle Creek and Clover Valleys, where most residents and agricultural areas are found. To the south of the watershed in the Rodman Slough and Reclamation areas, most water use comes from agricultural use of Clear Lake and Middle Creek waters.

The available studies of groundwater supplies and water use in Middle Creek and Clover Valleys indicate that groundwater overdraft is not currently a threat. On average years, only about 50% of the estimated safe yield of groundwater is being used. However, the estimate of groundwater availability is limited to one 1978 study, and additional studies could significantly improve understanding of these groundwater resources.

17.1.3 Reducing Wildland Fire Hazards

The most common perspective on wildland fire hazard reduction focuses on reducing the threat that fires from wildlands will threaten human lives, health, and property. Another perspective recognizes that high fuel loads, caused by decades of fire suppression, can lead to severe wildfires that damage terrestrial and aquatic wildlife habitats. The former perspective will be discussed in this section while the latter will be discussed in the section below.

The most populated areas of the Middle Creek Watershed lie in areas with low fire hazard (Plates 14 and 15). However, significant numbers of residences do occur in areas with moderate to high fire hazard along Rancheria Rd. and in Clover Valley. Scattered residences occur in upper watershed areas where fire hazard is very high.

Property owners, renters, and managers are required by law to maintain defensible space around buildings and residences. The Lake County CWPP, approved by the Lake County Board of Supervisors in August 2009, contains a wealth of information on fire risk and management in the county. The plan identified the need to improve water supplies for fire protection in Upper Lake, and it identified a number of high priority fuel reduction programs (Section 16.10). To insure that these priorities are met, and to continue the process of identifying and managing fire hazards, watershed residents can participate in the Lake County Fire Safe Council. Neighbors and communities can work together to create Firewise Communities to improve local fire safety.

17.1.4 Encouraging Abundant and Diverse Wildlife Populations

This section focuses on terrestrial wildlife, and the following section focuses on fish. However, there is some overlap in the sections, because many species use both types of habitats, and many human activities affect terrestrial and aquatic habitats.

Land uses that have had a large impact on wildlife habitat in the past, but are no longer as common and/or extensive, include conversion to agriculture, livestock grazing, logging, and in-stream gravel mining. Land uses that continue to have major potential impacts are discussed briefly below. They include on-going agriculture, road building and maintenance, introduction of invasive species, and OHV recreation. Increased use of fire by early settlers may have had a large impact on plant communities, but in recent decades fire suppression has been the major influence.

On-going agricultural operations have the potential to reduce streamflows due to spring and summer irrigation, reducing water available for terrestrial wildlife and aquatic organisms. The recent reduction in pear acreage in the Middle Creek Watershed has reduced water demand from agriculture.

The introduction and spread of invasive species is an on-going threat, and increased prevention, monitoring, and control are needed to minimize this threat.

One of the most significant ways in which upland habitats could be managed to improve wildlife habitat is through the use of prescribed burning. The forest management focus on fire suppression since about 1917 has led to high fuel loads. These high fuel loads threaten forested areas, including riparian trees. The Fork Fire in 1996 is an example of a large-scale fire that burned riparian areas along with large areas of forest and chaparral. The 1999 Watershed Analysis Report emphasized the importance of prescribed burning in chaparral areas, and fuel treatments such as thinning and under-burning in forested areas to reduce the threat of high intensity wild fires and protect wildlife habitat. Reducing fuel loads in forested areas will allow late successional forest areas, and the species that rely on them, to recover and expand. A reduction in the scale and intensity of fires will protect riparian areas that are vital to both terrestrial and aquatic wildlife. To the extent that prescribed burning of chaparral can prevent large scale fires while providing a constant supply of early successional brush stands, it could lead to healthy, stable deer populations.

17.1.5 Improving Native Fish Habitat and Populations

The extent of the contribution of roads and vehicle traffic to sedimentation of streams is not adequately documented on MNF or private lands. In particular, OHV use in unauthorized areas and in stream channels near the Middle Creek Campground (located at the confluence of the east and west forks of Middle Creek) may have significant impacts. MNF funding for road maintenance has declined substantially in recent decades.

There have been no recent studies of fish populations and stream conditions in the upper watershed. A past study (1980) described fish populations on the east fork of Middle Creek. Additional studies would provide a valuable comparison for this area and baseline conditions for other streams.

In the lower watershed, spawning migrations of the Clear Lake hitch and Sacramento pikeminnow have been greatly reduced relative to historic levels, and the Clear Lake splittail may be extinct. Recent volunteer monitoring has found a complete lack of hitch in Middle Creek in 2006 and 2007, and very low numbers in 2008 and 2009 (Section 11.2.1). Local residents have formed a CRMP group, the Chi Council, and efforts are underway to improve understanding of hitch biology and factors impacting their populations.

Although barriers on the main creeks have been identified, a thorough survey of barriers to fish passage on all smaller tributary streams is needed. Elimination of barriers (by removal or construction of ladders), is likely to be an important part of improving spawning success.

Stream sampling for pesticides is costly. Stream bioassessments and surveys use relatively simple methods to gage the ecological health of a stream system and offer opportunities for volunteer involvement. Creek walks and greenline surveys were carried out by the Middle Creek CRMP in 2005 and 2006 in lower Middle Creek. Bioassessments were made at one location in below the Clover Creek Diversion Channel in 2005 and 2006, and these also provide opportunities for volunteer participation and regular monitoring of aquatic and riparian habitats. Continuing these types of monitoring, and possibly expanding efforts to locations in the upper watershed could be an effective way to monitor aquatic habitat conditions.

17.1.6 Restoring Middle Creek below the Confluence

The MCCRMP, Robinson Rancheria Tribe, and other groups have focused efforts on restoring and documenting conditions in Middle Creek in the area of the confluence of the east and west forks and downstream to the Hunter Bridge area. This section of creek has been severely damaged by gravel mining and stream channelization in Upper Lake Valley, particularly construction of the USACE Middle Creek Flood Control Project in 1959-1966. Major additional efforts will be required to restore the creek channel and riparian vegetation. Restoration efforts thus far include a series of 10 small projects installed in 2000-2002, and the “dragon’s teeth” weirs installed in 2006 near the Middle Creek campground.

A first step to continuing creek restoration will be to assess the success of the restoration projects implemented in 2000-2002. Depending on the success of these projects, additional small-scale projects may be warranted, or taking a larger-scale, more comprehensive approach may be needed. Under this approach stream restoration would be carried out in sections delineated by control points, for example from where the streambed narrows about 2 miles above the confluence, down to the confluence, then from the confluence about one mile downstream to where the streambed narrows again, and so on. Below the confluence, restoration projects are complicated because of ownership by numerous private landowners.

17.2 Information and Data Gaps

- Causes and locations (sub-watershed) of erosion and sedimentation.
- Riparian and aquatic habitat conditions in the upper watershed.
- Condition of 2000-2002 restoration projects on lower Middle Creek.

- Barriers to Clear Lake hitch passage in tributaries to Middle Creek.

17.3 Recommendations

- Survey roads and trails outside MNF for erosion potential.
- Improve road and trail maintenance. Decommission and reconstruct roads and OHV trails as needed to reduce erosion.
- Evaluate riparian and aquatic habitat conditions in the upper watershed. Priority should be east fork of Middle Creek, followed by the west fork of Middle Creek and other streams.
- Evaluate OHV impacts on aquatic and riparian systems from sedimentation and travel in and adjacent to stream channels.
- Re-route or otherwise manage OHV travel to prevent stream damage.
- Complete summarizing and evaluating data from creek walks and greenline surveys on lower Middle Creek.
- Continue systematic surveys of lower Middle Creek to evaluate changing stream conditions.
- Continue restoration of Middle Creek below the campground.
- Extend bank stabilization near Middle Creek Campground.
- Organize multi-jurisdictional survey of Middle Creek and its major tributaries for Arundo, Tamarisk, and tree-of-heaven.
- Increase prescribed burning of chaparral to improve wildlife habitat and streamflows and reduce the threat of catastrophic wildfire.
- Update the Upper Lake groundwater basin investigation.
- Complete the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project, which would reduce sediment loads from the Middle Creek Watershed to Clear Lake.

18. Glossary

Term	Definition	Source
303(d) List	Refers to section 303(d) of the Clean Water Act that requires each state to periodically submit to the United States Environmental Protection Agency (USEPA) a list of impaired waters. Impaired waters are those that are not meeting the State's water quality standards. Once the impaired waters are identified and placed on the list, section 303(d) requires that the State establish total maximum daily loads that will meet water quality standards for each listed water body.	SWGP
Acre-ft	A unit of volume commonly used in the United States in reference to large-scale water resources. It is a volume equivalent to the area of one acre (43,560 square feet) covered to a depth of one foot.	W
Alluvial material, alluvium	Soil or sediments deposited by a river or other running water.	W
Anadramous fish	Fish who live mostly in the ocean and breed in freshwater.	w
Annual flow	The rate at which water flows through a channel, determined by averaging daily measurements of the flow during one entire year.	
Aquifer	An underground layer of porous, water-bearing rock, gravel, or sand.	MDC
Aquifer, confined vs. unconfined	**Unconfined** aquifers are covered by permeable geologic formations. They receive recharge water directly from the surface, from precipitation or from a body of surface water (e.g., a river, stream, or lake) which is in hydraulic connection with them. **Confined** aquifers have an impermeable layer at their upper boundary and are typically found below unconfined aquifers. Confined aquifers can be under pressure causing artesian wells, where water rises in the well, sometimes to the land surface.	W
Benthic	Bottom-dwelling; describes organisms which reside in or on any underwater substrate.	MDC
Benthic macroinvertebrate	Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro). They include crayfish, mollusks, aquatic worms, and the immature forms of aquatic insects, for example stonefly and mayfly nymphs.	MDC
Channelization	The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.	MDC
Chaparral	A shrubland (brush land) plant community found primarily in California. A typical chaparral plant community consists of densely-growing evergreen scrub oaks and other drought-resistant shrubs. It is a fire prone plant community with many fire-adapted species.	W
Confluence	The location at which two streams intersect and begin to flow as one larger stream.	CWMP
Cubic feet per second (cfs)	A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second).	MDC
Defensible space	Area around a structure that has been landscaped and managed to reduce fire danger.	W
Dissolved oxygen	The concentration of oxygen dissolved in water. Dissolved oxygen is a measure of the biological activity of water masses.	MDC
Diversion	A temporal removal of surface flow from the channel	CA SSHRM
Downcutting	When a stream channel deepens over time.	CWMP
Endangered	In danger of becoming extinct.	MDC
Ephemeral stream	A stream or portion of a stream that flows only in direct response to precipitation, receiving little or no water from springs and no long continued supply from snow or other sources, and whose channel is at all times above the water table.	SAF
Eutrophic	Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae. Decay of this plant life often leads to low dissolved oxygen content. Lakes can be naturally eutrophic or can become eutrophic due to human activities that increase water nutrient levels.	MDC
Eutrophication	The process of increasing nutrient and decreasing oxygen supply within a water body.	CWMP

Fault	In geology, a fault or fault line is a planar fracture in rock in which the rock on one side of the fracture has moved with respect to the rock on the other side. Large faults within the Earth's crust are the result of differential or shear motion and active fault zones are the causal locations of most earthquakes. Earthquakes are caused by energy release during rapid slippage along a fault.	W
Flood	Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain.	CA SSHRM
Flood Peak	The highest amount of flow that occurs during a given flood event.	CWMP
Floodplain	The flat area adjoining a river channel constructed by the river in the presence of a given climate, and overflowed at times of high river flow.	CWMP
Geomorphology	The scientific study of landforms and the processes that shape them.	W
Groundwater	Water that is located beneath the ground surface in soil pore spaces and in the fractures of lithologic formations.	CWMP
Headwaters	The small streams and upland areas that are the source of larger streams and rivers. The most distant point in the drainage basin from the river or stream mouth.	CWMP, W
Hydrology	The study of the movement, distribution and quality of water throughout the earth (and atmosphere).	W
Impaired water body	Surface waters identified by the Regional Water Quality Control Boards as impaired because water quality objectives are not being achieved or where the designated beneficial uses are not fully protected after application of technology-based controls. A list of impaired water bodies is compiled by the State Water Resources Control Board pursuant to section 303(d) of the Clean Water Act (CWA).	SWGP
Incised (channel)	Deep, well defined channel with narrow width to depth ratio, and limited or no lateral movement. Often newly formed, and as a result of down-cutting in the substrate.	MDC
Infiltration (water)	Entry of water into soil or other material at the earth's surface.	CWMP
Intermittent stream	A stream, or portion of a stream, that does not flow year-round but only when it (a) receives base flow solely during wet periods, or (b) receives groundwater discharge or protracted contributions from melting snow or other erratic surface and shallow subsurface sources.	SAF
Invasive species	Plant or animal species from another geographic region that once introduced out-compete native plants or animals and take over a habitat area.	CWMP
Land use	Typically a group of similar on-the-ground human uses described as a single category.	CWMP
Meandering	When a stream channel has a winding or sinuous path.	CWMP
Metamorphic rock	Metamorphic rock is one of the three main rock types. (The others being sedimentary and igneous.) Itis the result of the transformation of an existing rock type by heat and pressure (temperatures greater than 150 to 200 °C and pressures of 1500 bars[1]) causing profound physical and/or chemical change. The existing rock may be sedimentary rock, igneous rock or another older metamorphic rock.	W
National Pollutant Discharge Elimination System (NPDES) Permit Program	Controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Since its introduction in 1972, the NPDES Permit Program has been responsible for significant improvements to our Nation's and State's water quality.	SWGP
Non-native species	Plant or animal species introduced to an area from another geographic region.	CWMP
Non-point Source (NPS) Pollution	Water pollution that does not originate from a discrete point, such as a sewage treatment plant outlet. NPS pollution is a by-product of land use practices, such as those associated with farming, timber harvesting, construction management, marina and boating activities, road construction and maintenance, and mining. Primary pollutants include sediment, fertilizers, pesticides and other pollutants that are picked up by water traveling over and through the land and are delivered to surface and ground water via precipitation, runoff, and leaching. From a regulatory perspective, pollutant discharges that are regulated under the National Pollutant Discharge Elimination System Permit (NPDES) are considered to be point sources. By definition, all other discharges are considered NPS pollution.	SWGP
Peak flow	The maximum instantaneous rate of flow during a storm or other period of time.	CWMP

Perennial stream	A stream that has running water on a year-round basis under normal climatic conditions.	SAF
Planktivore	A general term to describe an organism adapted to feeding primarily on plankton (drifting organisms in water).	W
Plate (tectonic)	Large sections of the Earth's lithosphere (outer-most, rocky layer). There are currently 8 major (for example the North American and Pacific Plates) and many minor plates.	W
Precipitation	The liquid equivalent (inches) of rainfall, snow, sleet, or hail collected by storage gages.	CWMP
Prescribed burning	Also know as controlled or hazard reduction burning or prescribed fire. Usually conducted during the cooler months to reduce fire fuel buildup and decrease the liklihood of serious, hotter fires.	W
Recurrence Interval (return interval)	Determined from historical records. The average length of time between two events (rain, flooding) of the same size or larger. Recurrence intervals are associated with a probability. (For example, a 100-year flood would have a 1% probability of happening in any given year.)	CWMP
Riparian Area	Interface between land and a stream.	W
Riparian Vegetation	Vegetation growing on or near the banks of a stream or other body of water in soils that are wet during some portion of the growing season.	CWMP
Sediment	Fragments of rock, soil, and organic material transported by and deposited into streambeds by wind, water, or gravity.	CWMP
Sedimentary rock	Sedimentary rock is one of the three main rock types (the others being igneous and metamorphic rock). Sedimentary rock is formed by deposition and consolidation of mineral and organic material and from precipitation of minerals from solution. The processes that form sedimentary rock occur at the surface of the Earth and within bodies of water.	W
Sedimentation	The deposition or accumulation of sediment.	CWMP
Siltation	To fill up with silt or other fine sediments.	
Stakeholder	A person, group, organization, or system who affects or can be affected by an action.	W
Stormwater	Water generated by runoff from land and impervious surfaces during rainfall and snow events that often contains pollutants in quantities that could adversely affect water quality. Dry weather flow enters the municipal storm sewer from every day activities such as lawn watering, car washing, and ground water seepage.	CWMP
Stream degradation	When a stream, or section of stream, is removing more material than it is depositing. The level of the streambed is dropping, and usually the banks are eroding.	
Stream gage	A stream gauge, or stream gage, refers to a site along a stream where measurements of volumetric discharge (flow) are made.	
Stream gradient	The change of a stream in vertical elevation per unit of horizontal distance.	MDC
Streamflow	The active flow of water within a stream, river, or creek. The volume of water passing a given point per unit of time.	CWMP
Subduction	In geology, subduction is the process that takes place at convergent boundaries by which one tectonic plate moves under another tectonic plate, sinking into the Earth's mantle, as the plates converge.	W
Substrate	The mineral and/or organic material forming the bottom of a waterway or waterbody.	MDC
Sub-watershed	Watersheds drain into other watersheds in a hierarchical form, larger ones breaking into smaller ones, or sub-watersheds, with the topography determining where the water flows.	W
Surface runoff	Water that runs across the top of the land without infiltrating into the soil.	CWMP
Surface water	Water that is flowing across or contained on the surface of the earth, such as in rivers, streams, creeks, lakes, and reservoirs.	CWMP
Sustainable	Resources must only be used at a rate at which they can be replenished naturally.	SWGP
Threatened species	A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.	MDC
Total Maximum Daily Load (TMDL)	A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. TMDL's are required for water bodies on the 303(d) list.	
Tributary	A stream feeding, joining, or flowing into a larger stream or into a lake.	

Turbidity	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air.	W
Upland	Describing high or hilly country.	
Watershed	The total land area that water runs over or under when draining to a stream, river, pond, lake, or other designated point.	MDC
Weir	A low dam placed in a river or stream to raise its level, divert its flow, or gage the flow of water.	CWMP

	Sources of Definitions
CA SSHRM	CA Department of Fish and Game Salmonid Stream Habitat Restoration Manual <http://www.dfg.ca.gov/fish/REsources/HabitatManual.asp>
CWMP	Carlsbad Watershed Management Program <http://www.carlsbadwatershednetwork.org/cwmp.php> (Accessed 03.10.09).
MDC	Missouri Department of Conservation, MDC.online watershed glossary. http://mdc.mo.gov/fish/watershed/glossary.htm (Accessed 03.10.09)
SAF	Society of American Foresters. The Dictionary of American Forestry <http://dictionaryofforestry.org/dict/browse> (Accessed 07.14/09)
SWGP	Proposition 84 Storm Water Grant Program, Draft Final RFP
W	Wikipedia - Free online Encyclopedia

19. Acronyms & Abbreviations

BLM	United States Bureau of Land Management
CAL FIRE	California Department of Forestry and Fire Protection
LCCDD	Lake County Community Development Department
CDFA	California Department of Food and Agriculture
CEQA	California Environmental Quality Act
CLTSC	Clear Lake TMDL Stakeholder Committee
CNDDB	California Natural Diversity Database
CRMP	Coordinated Resource Management Planning
CVRWQCB	Central Valley Regional Water Quality Control Board
CWPP	Community Wildfire Protection Program
DFG	(California) Department of Fish and Game
DWR	(California) Department of Water Resources
EIR	Environmental Impact Report
FEMA	Federal Emergency Management Assistance
IRWMP	Integrated Regional Water Management Plan
LCAD	Lake County Agriculture Department
LCPWD	Lake County Public Works Department
LCWIA	Lake County Water Inventory and Analysis
LCWMA	Lake County Weed Management Area
LCWPD	Lake County Watershed Protection District
MCCRMP	Middle Creek Coordinated Resource Management (group)
Middle Creek Project	Middle Creek Flood Damage Reduction and Ecosystem Restoration Project
MCMA	Middle Creek Management Area (MNF Forest Plan)
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service (formerly SCS)
OHV	Off-Highway Vehicle
RCD	Resource Conservation District
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
Watershed Analysis Report WDR	Watershed Analysis Report for the Upper Lake Watershed Waste Discharge Requirements
WUI	Wildland Urban Interface

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Persons Cited as Personal Communication

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